This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

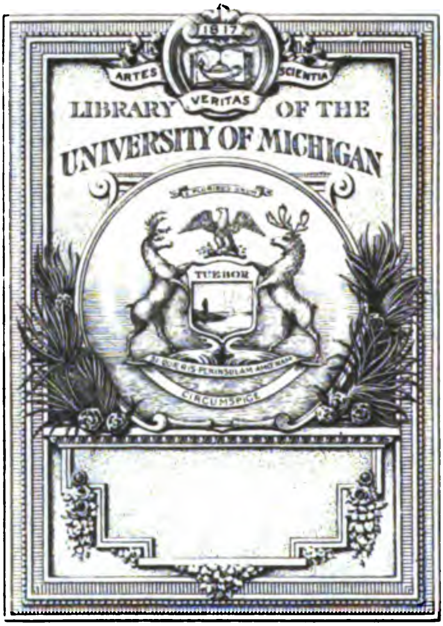
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


1817
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

S
97
.E2

THIRTIETH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1907,

Including Scientific Papers and Bulletins Nos. 195, 196.

West Raleigh, North Carolina.

RALEIGH:
PRESSES OF EDWARDS & BROUGHTON PRINTING CO.
1908.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

S. L. Patterson, *ex officio* Chairman, Raleigh.

C. W. Mitchell	Aulander.	**A. T. McCallum**	Red Springs.
J. J. Laughinghouse	Greenville.	**J. P. McRae**	Laurinburg.
William Dunn	New Bern.	**R. L. Doughton**	Laurel Springs.
Ashley Horne	Clayton.	**W. A. Graham**	Machpelah.
R. W. Scott	Melville.	**A. Cannon**	Horse Shoe.

STATION STAFF

George T. Winston, LL.D., President of the College.

B. W. Kilgore	Director.
W. A. Withers	Chemist.
Tait Butler	Veterinarian.
F. L. Stevens	Biologist.
C. B. Williams	Agronomist.
C. M. Conner	Agriculturist.
W. N. Hutt	Horticulturist.
J. S. Jeffrey	Poultryman.
Franklin Sherman, Jr.	Entomologist.
Wm. Kerr	Assistant in Field Experiments.
J. C. Kendall	Assistant in Dairy Husbandry.
W. A. Syme	Assistant Chemist.
F. C. Reimer	Assistant Horticulturist.
J. G. Hall	Assistant in Plant Diseases.
A. F. Bowen	Bursar.

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

General

FEB 13 '40

TABLE OF CONTENTS.

PAGE.
Board of Trustees and Experiment Station Staff 2
Letter of Transmittal 5
Letter of Submittal 6
Report of Director 7
  Report of the Agricultural Division 11
  Report of the Chemical Division 13
  Report of the Biological Division 15
  Report of the Veterinary Division 19
  Report of the Poultry Division 23
  Report of the Entomological Division 24
  Financial Statement for the Year Ending June 30, 1907 26
Scientific Papers—
  Spraying Irish Potatoes 27
  A Bacterial Disease of Lettuce 29
  Sclerotia on Carrots 31
  The Chrysanthemum Ray Blight 33
  Inoculation with Tubercle Bacteria:
    Brief History Concerning Relation of the Root Tubercles to Nitrogen Gathering 48
    Early Field Inoculations 48
    Objections to the Use of Soil as a Medium of Inoculation 49
    When Inoculation is Necessary or Desirable 49
    Inoculation by Pure Culture 50
    The Method of Liquid Cultures:
      a. Availability of the Liquid Cultures 51
      b. Purity of the Cultures After Multiplication 52
      c. Pot Experiments 52
    Summary 57
  Notes on Plant Diseases in North Carolina 58
Press Bulletins—
  A Serious Lettuce Disease 71
  Treatment of Oats, Wheat, Rye and Barley (Revised) 73
Bulletins—
  Number 195, Farm Poultry
  Number 196, Some Apple Diseases.

LETTER OF TRANSMITTAL.

RALEIGH, N. C., June 30, 1907.

To His Excellency, ROBERT B. GLENN,
Governor of North Carolina.

SIR:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July, 1906, and ending June 30, 1907.

Very respectfully,

S. L. PATTERSON,
Chairman Board of Trustees.

LETTER OF SUBMITTAL.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,
RALEIGH, N. C., June 30, 1907.

HON. S. L. PATTERSON, *Chairman Board of Trustees.*

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1907.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. KILGORE,
Director.

THIRTIETH ANNUAL REPORT

OF THE DIRECTORS OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1907.

By the Director.

This report covers the work of the Station from July 1, 1906, to June 30, 1907.

CHANGES IN STATION STAFF.

H. H. Hume, Horticulturist, severed his connection with the Station on September first and his place was filled by the election of W. N. Hutt. R. H. Harper and O. L. Bagley resigned as assistant chemists and were succeeded by W. A. Syme. The work of C. W. Burkett as Agriculturist has been carried on by C. B. Williams and C. M. Conner. R. S. Woglum, Acting Entomologist, was succeeded by Franklin Sherman, Jr., as Entomologist.

WORK IN THE AGRICULTURAL DIVISION.

The operations in this Division of the Station have been mainly in continuation of the experiments of the previous years in testing cotton, corn, cowpeas, and soja beans with a view of determining the varieties best suited to our conditions, their fertilizer requirements and methods of cultivating and handling the crops and their improvement by careful selection. The work with alfalfa has been enlarged to meet the increased interest in this crop, and a considerable amount of work with grains, especially wheat and oats, has been inaugurated.

WORK IN THE CHEMICAL DIVISION.

In the Chemical Division study has been continued of nitrogenous fertilizer materials and the conditions under which they are converted into food most suitable for crops, together with the bacteria which bring this about. This work is being done in co-operation with the Biological Division.

Some work has been done with the sweet potato to determine its suitability for the production of alcohol and analyses have been made of samples for nitrogen, formaldehyde, nitrates, etc., in connection with other work.

WORK IN THE BIOLOGICAL DIVISION.

The diseases to which plants are subject are either increasing annually, or else we are only finding from year to year ones which have long been with us. Investigations have been continued this year in the study of watermelon wilt, in efforts to obtain one or more varieties which would resist this disease and at the same time have good shipping and eating qualities. This work has been in progress for several years, in co-operation with the U. S. Department of Agriculture. Some good melons have been obtained, but they have not been grown sufficiently long to have their qualities fixed.

Granville tobacco wilt studies have been continued in that section. A large number of varieties have been tested, a few of which have shown good qualities of resistance. No method of combatting the disease has yet been found, though the nature of the trouble is known to us.

In the eastern part of the State, particularly in Chowan county, considerable damage is done by a sweet potato wilt. Investigations on this were begun last season. Arrangements have been made for a continuation of this the present year.

Investigations have been conducted on soil bacteriology in co-operation with the Chemical Division, tests being made of a large number of cultures for inoculating leguminous crops and a collection of the fungus diseases of the State begun.

A new disease of chrysanthemums has been found and possibly a method of combatting it.

The most important scientific investigations under way are in connection with apple diseases and lettuce drop. Several new diseases of the apple have been found, among them being disease of the fruit, a fruit rot, a disease of the twigs, a trunk rot, and a canker disease. Studies are being made of these along with troubles already known, among which are the apple leaf spot, the apple rust, and black rot, together with methods of overcoming these troubles.

In connection with the lettuce drop extensive experiments at New Bern have been conducted to test various methods for the treatment of the bed with a view of the extermination of the disease. These experiments have included heat and different chemicals.

The correspondence of this division of the Station has been large, which is good evidence of its usefulness.

WORK IN THE VETERINARY DIVISION.

The work in the Veterinary division is largely provided for by the State Department of Agriculture, a portion of the salary of the Veterinarian only being paid by the Station.

The main efforts of the Veterinarian have been directed toward the extermination of the cattle or fever tick. Methods have been worked out which are being applied on a large scale with most satisfactory results, several counties being freed each year from this pest and relieved from the quarantine restrictions. A great deal of attention is given to the general live stock interests of the State and to the suppression of contagious diseases.

WORK IN THE POULTRY DIVISION.

The poultry work has proceeded along the usual lines of testing different breeds for comparative egg production, methods of preserving eggs, including the keeping qualities of fertile and infertile eggs, methods of handling and feeding and care of chickens; the use of different incubators and brooders; and special work in pedigreed fowls for egg production. In this latter trap nests have been used and a record of all hens kept. These have shown some of the hens to be specially prolific layers, while others have given no eggs. The eggs from the heavy layers last year and this have been hatched separately and the chickens so marked that the best of them can be selected for a continuation of this work. This is a line of especial interest and value in poultry production.

A comparison has been made of dry and wet mash feeding with results favorable to dry feeding, as indicated by the specially good health of the fowls and the increase of eggs from dry fed fowls. There is a large saving of time in dry feeding.

Tests have also been made of the value of green feed for laying stock.

A Bulletin on Farm Poultry has been prepared giving in addition to matters of general interest to the poultry raiser, the more important results of the experimental work referred to above.

An additional building has been added the past season for keeping male birds and a windmill for supplying water. The barns and poultry houses have been painted.

The correspondence and calls for the Poultryman's services, together with the Institutes which he has attended, show a growing interest in the poultry work; the correspondence the past year amounted to something like a thousand letters.

WORK IN THE ENTOMOLOGICAL DIVISION.

With the exception of a part of the salary of the Entomologist, the entomological work is provided for by the State Department of Agriculture. The most serious insect pest to fruit crops is the San Jose scale. Experiments have been made this season in a number of orchards, especially that of the Candor Fruit Company, in Montgomery County, where over thirty thousand trees were treated, with "Scaleicide" with good results.

Preliminary experiments in the control of plum and peach curculio by spraying with arsenate of lead in water or the Bordeaux mixture have also been made with good results, though it is desirable to continue this work another season before drawing conclusions.

Arsenate of lead in water has proven itself very effective in the destruction of the tobacco flea beetle on young plants.

Study has been made of cabbage insects, especially the cabbage louse, harlequin cabbage bug, and the white cabbage butterfly.

These investigations will be continued as time permits.

DAIRY WORK.

Under the direction of Prof. C. M. Conner, Mr. Kendall has made experiments on the acid content of milk, the effect of the period of lactation, and of acid food, on the acidity of fresh milk; and a feeding experiment to compare the value of saccharine feed with wheat bran; treatment of milk and cream contaminated with garlic and means of preventing it; a study of the normal composition of North Carolina milk, and the preparation of records of dairy herd of grade and scrub cows with a view of its improvement by selection and breeding.

PUBLICATIONS.

Bulletins have been issued as follows:

No. 195.—Farm Poultry, by J. F. Jeffrey.

No. 196.—Some Apple Diseases, by F. L. Stevens.

The reports of the heads of the several divisions of the Station and financial statement follow:

REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director*.

DEAR SIR:—The following are the main lines of work that are being conducted in this Division:

Alfalfa.—For some time past greatly increased interest has been manifested throughout the State in the growth of alfalfa, and as a result, during this time many inquiries from different localities concerning the value and adaptability of this plant to North Carolina conditions, as well as to the proper method of preparation of soil, time of planting, kind and amount of fertilizer to use, etc., have been received. In response to this popular demand for definite information eighteen experiments designed especially to study the fertilizer requirements of this legume when grown upon our soils have been put out during the past year. In addition to these, five other plats were sown to alfalfa seed from as many different sources and of as many different varieties to ascertain the varieties best suited to our conditions of soil and climate.

Clovers, Cowpeas and Soy Beans.—During the year fifteen plats have been sown to alsike, mammoth, medium red, crimson and white blooming crimson clovers, the plats being so arranged and treated as to study in a comparative way the response in yield of hay of each clover to different fertilizer treatments. Thirty varieties of cowpeas and thirty-four of soy beans are being tested to determine what ones are most prolific of seed and hay.

Wheat and Oats.—Ten leading varieties of wheat and six of oats are being tested on one-twentieth acre plats under the same soil and fertilizer treatment to ascertain their relative yields. As these two cereals are grown to a considerable extent in the State the use of the most prolific varieties is of the most vital importance.

Cotton and Corn.—With these there are thirty-eight one-twentieth acre plats being devoted to fertilizer tests of cotton and thirty-two to corn. The fertilizing constituents on these plats are combined in different proportions so that the most economical fertilization may be determined for these crops. In addition to these, six plats are used for culture tests; fifteen for rotation tests; sixteen for distance tests of cotton and corn; and thirty-four for variety tests of corn.

Breeding Tests of Corn.—Several plats are given over to a study of the effect of selection of corn upon yield. This work was begun three years ago by selecting during the fall seed for the following year's planting from one-eared, two-eared, three-eared and four-eared stalks, and planting each of these selections in different plats. The appropriate selection of seed from the different plats is being continued and the yield of seed corn from each plat is recorded.

For instance, on the plat planted in corn that was produced o that were only one to the stalk, the selection of seed for next planting from this plat was from stalks bearing only one ea stalk; and so on for the two, three and four-eared kinds.

There is no more vital subject for our farmers than that o selection made in the proper way.

While the agricultural work has been increased this year, of the experiments referred to above have been under way for a ber of seasons, and will be continued until sufficient data has collected to justify a publication of the results.

Respectfully submitted,

C. B. Williams,
Agronomi

REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—I take pleasure in submitting the following report of the operations of the Chemical Division during this year.

The main work of the Division has been a continuation of the study of nitrification in the soil, and in this work we have been greatly helped by the co-operation of the Bacteriological Division and the appointment of Mr. Temple as special assistant. In addition to the study of nitrification we have made some investigations of the sweet potato, have made determinations of nitrogen in samples sent out by the referee of the Association of Official Agricultural Chemists, and of formaldehyde in some samples of the commercial article for the Bacteriological Division, have made an analysis of soil for the Bacteriological Division, and have determined the amounts of nitrates and nitrites in the garden soils of the neighborhood. Of these it will be necessary to refer to only a few.

Sweet Potato.—Alcohol is produced from the sweet potato by transforming the starch into sugar and by fermenting the sugar. The sweet potato has not been used in the United States for making alcohol, although the percentage of starch in it is greater than in the Irish potato. The sweet potato contains a considerable quantity of cane sugar already made. The climate of the Southern States is peculiarly adapted to the growing of sweet potatoes, and North Carolina leads in their production. It would seem then that the alcohol industry would be very profitable in the South if there were an economical method for the use of the sweet potato for this purpose. Experiments at the South Carolina Station show that as high as eleven thousand pounds of sweet potatoes can be grown per acre under intensive cultivation. In the potatoes grown in these experiments over twenty per cent of starch was found, and in addition to this as high as six per cent of fermentable sugar. There ought to be produced about one gallon of alcohol from a bushel of sweet potatoes, or 200 gallons per acre. The composition of the sweet potato is shown by analysis at the California and Texas Experiment Stations (17 varieties of each) is as follows:

	Cal.	*Texas.*
Water	70	70
Ash	1.08	1.14
Protein	1.86	2.41
Fat	0.95	0.99
Total sugar	5.95	6.81
Nitrogen free extract	23.60	24
Fiber	2.51	2.26

W. E. Stone, of Purdue University, made an investigation of the sugars in the sweet potato and showed that there are no reducing sugars present, but he found cane sugar to the extent of one and one-half to two per cent. He studied also the effect of baking and found that during cooking a considerable quantity of starch was changed to the soluble form.

The experiments made in this laboratory confirmed the results of Stone as to the presence of cane sugar in the sweet potato, and seemed to show further that there is no reducing sugar present. This was tested in two ways.

The absence of pentosans and pentoses has been shown in this laboratory. This was not touched upon by Stone.

It appears to us from these experiments that there is no reason why the sweet potato might not be used directly for the production of alcohol rather than by taking the usual step of separating the sugar and the starch and producing alcohol from them, the carbohydrates in the potato being starch and cane sugar.

Nitrification.—At the beginning of the work of the Division on nitrification we found it possible to produce nitrates in soils from nearly every soil tested by us, but during the last year or so we have found that the same fields and gardens failed to produce nitrates, which indicates not only instability in the organism but the lack of wide distribution. After failing to find it in the ordinary field and garden soils of the vicinity, we took some very rich soils and succeeded again in securing the formation of nitrates. In some cases we have found that an attempt to cultivate the organism has resulted in the lack of production of nitrates. After succeeding in locating the organisms, our work is now proceeding in a satisfactory way in co-operation with the Bacteriological Division. Dr. Stevens and Mr. Temple are attempting to cultivate and isolate the different organisms in the soils referred to with the view of ascertaining those which produce nitrates. This Division is performing the analytical work, and Mr. Temple is for the present giving himself entirely to the bacteriological work. Our experiments indicate that we shall have interesting results.

Respectfully,

W. A. Withers,
Chemist.

REPORT OF THE BIOLOGICAL DIVISION.

Mr. B. W. Kilgore, *Director*.

Dear Sir:—I beg leave to submit a report of the Division under my charge for the fiscal year now closing.

This Department as organized embraces the subjects, Vegetable Pathology and Bacteriology in the Experiment Station and the same subjects, with Botany in addition, in the Agricultural College. The addition of J. G. Hall to the staff as assistant in plant pathology has made it possible to do much more work with plant diseases than ever before; and the employment of J. C. Temple as assistant in bacteriology has admitted of work in soil bacteriology. I wish to express my appreciation of the ability, interest and enthusiasm of Messrs. Temple and Hall in their respective fields of work, and to acknowledge their efficient aid in carrying on the work of this year as planned.

This Department is well housed in the laboratories of the Agricultural Building, and well equipped with work benches, herbarium cases, miscroscopes, microtomes, incubators, sterilizers and necessary small utensils. An incubator provided with several compartments, each of different temperature, giving a range from 0° to 35°C, has been installed recently; a complete set of *Fungi Columbiani* and *Saccardo's Sylloge Fungorum,* has been secured, also complete bound sets of *Centralblatt für Bacteriologie, Annales Mycologici, Zeitschrift für Pflanzenkrankheiten.*

An excellent incubator room has been constructed. It is lined throughout with metal and asbestos, insulated by four inches of air space on all sides, and is fitted with shelves and lockers made by the Art Metal Construction Company, of Chautauqua, N. Y.

According to the plan (Fig. 1) three kinds of compartments are here provided: Open shelves *a;* Research closets *b,* size 20 by 50 inches, containing three shelves each and provided with lock; and the individual lockers *c,* 5 by 15½ inches, provided with doors but without locks. This arrangement of incubator room gives more space than many ordinary incubators and at very much less expense. The room is heated by a special stove, "Petite Calorifer á gaz," regulated by a Roux U-shaped metallic regulator, "Grande Model," both procured from Weisnegg, Paris.

With these new facilities this department will be enabled to take up more extensive work in plant diseases and bacteriology during the coming year.

The work of the past year may be summarized as follows:

Publications.—During the year the following bulletins have been issued by this Department: Press Bulletin, No. 14, A Serious Lettuce Disease; Press Bulletin, No. 4, Treatment of Oats, Wheat, Rye

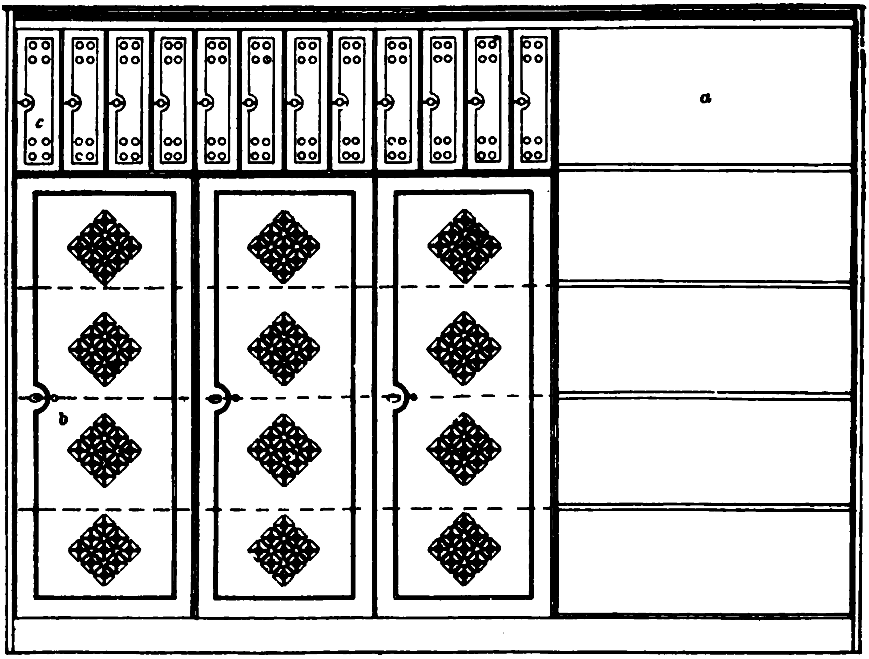


FIG. 1.—Showing arrangement of iron shelving of the incubator.

and Barley for Smut, has been revised and re-issued as No. 15; Bulletin No. 196, Some Apple Diseases, treating of several diseases of the apple tree, hitherto undescribed.

Correspondence.—Many inquiries concerning plant diseases have been received, diagnoses made, treatments recommended, etc. In all 3,743 letters have been mailed from this Department.

A Collection of Fungi for the Experiment Station has been begun, and it is desired to increase this collection as rapidly as possible. The specimens are being properly arranged and systematically cared for, so as to make them of working value.

Plant Disease Survey in Cooperation with the National Department of Agriculture.—Many queries have been sent out over the State concerning the prevalence, and amount of damage caused by various plant diseases. The information thus secured is properly tabulated and preserved for reference.

Lettuce Drop.—This is unquestionably the worst disease affecting the lettuce industry. Extensive laboratory and field study is planned, has been under way for the past year, and will be continued during the coming year.

Apple Diseases.—The fruit diseases of North Carolina have never been studied systematically, and much remains to be discovered concerning them. The apple diseases have, and will during the coming year, receive particular attention. Two new diseases have already been described and several more are under study in the laboratory to be reported upon later.

Root Tubercle Inoculations.—The widespread interest in soil inoculation, by various means, to secure an abundance of tubercles upon the roots of leguminous crops, and in particular the recent exploitation of the means of inoculation by the use of germs upon cotton lint and germs in liquid culture, have led us to test the efficiency of the most recent form of inoculation, that of liquid cultures. Very numerous accurate tests were made with the bean, cowpea, sweetpea, alfalfa, Canada field pea, vetch and red clover, both upon sterilized and unsterilized soil, inoculated and uninoculated, employing various modes of inoculation. In all some one hundred and ten experiments were made, throwing much light upon the question of inoculation by means of pure cultures. The results of this work will be found on succeeding pages.

Oat Smut.—The dissemination of knowledge concerning the available methods for preventing oat smut has been part of the work of this Department for the past five years. Many reports of efficiency have been received from farmers throughout the State and several laboratory tests have been made. The results of this work will soon be embodied in bulletin form.

Soil Bacteriology.—In co-operation with the Chemical Department, work has been undertaken in the study of soil organisms in their relation to nitrogen. So far the work has been largely of a preliminary character. A report of results will be made later.

Sweet Potato Wilt.—A large number of varieties of sweet potato has been secured through the kindness of the United States Department of Agriculture, and are under cultivation in Perquimans County. The work of last year consisted simply in increasing the stock of each variety on hand. The test of resistance of these varieties will be made this year.

Melon Breeding for Resistance to the Wilt.—Work on melon breeding was continued in co-operation with the National Department of Agriculture. Some thirty-four varieties of resistant melons were tested on sick soil to ascertain their edibility. At planting time and throughout the growing season conditions were adverse to successful melon growing, both in our experimental plots and on adjoining farms. For this reason many of the plots failed completely to produce a crop.

All melons planted possessed considerable resistance, in some cases almost complete resistance to the wilt, but in many strains the citron type predominated to a large extent. In other strains man melons were produced. In all cases, however, the variation great as to interfere with the value of the melon commerciall variety which has made a good record in previous years, th produced many edible melons of excellent quality and the vin of higher resistance to the wilt. The chief objection to this its lack of uniformity. Eighteen selections of seed were m future tests.

Respectfully submitted,

F. L. STEVENS,
Biolo

REPORT OF THE VETERINARY DIVISION.

DR. B. W. KILGORE, *Director.*

DEAR SIR:—Pursuant to your request, I have the honor to herewith submit my report as Veterinarian of the North Carolina Station for the year ending June 30, 1907.

The eradication of the cattle fever tick (Boophilus annulatus) continues to be the most important veterinary and animal husbandry question of special interest to North Carolina agriculture and the work of this Division has been continued along the lines followed in previous years, with the view of ascertaining the best methods of accomplishing this object.

For five years this Station, in cooperation with the North Carolina State Department of Agriculture, continued the work of cattle tick eradication, this State being practically alone in the work of applying the facts previously worked out by scientists regarding the habits and life history of the tick, to practical methods of destroying these parasites and our work first demonstrated the feasibility of the complete extermination of the cattle tick over large areas.

The two general methods developed and found most satisfactory have been outlined in previous reports, and briefly stated are as follows:

The first method involves the keeping of all cattle, horses and mules out of the pasture to be cleaned for such a period as will insure the death of all ticks from starvation. If these animals are taken out of a pasture September 1st and not returned until May 1st, it will be free of ticks. Or if they be taken out of the pasture May 1st it will be free of ticks by September 1st.

The winter period, although twice as long, is preferable for the following reasons: The ticks are more numerous and do the cattle more injury during September, October and November; the pastures afford less feed during the long winter period than during the best pasture months, May, June, July and August; and since the cattle carry few ticks May 1st, they are much more easily cleaned before putting on the tick-free pasture. If the cattle owner has only one pasture he may still clear it of ticks by any one of the following plans: He may arrange with a neighbor to pasture his cattle during one period, while he pastures those of his neighbor during the other period, thereby clearing both pastures. Or he may reduce the number of his cattle and divide his pasture by a fence, pasturing one part during one period and the other part the next period. If he does this and the fence be of wire, it will be necessary to move the fence back ten or fifteen feet onto the tick-free portion when the clean cattle are put thereon, for ticks sometimes cross wire fences. Or he may dispose of all cattle except a milch cow or two and stake these out or keep them in a small lot and feed them for one or the other of these periods. If none of these plans can be followed, it will pay any man to dispose of all his cattle and be without cattle for one of these periods in order to obtain a tick-free pasture.

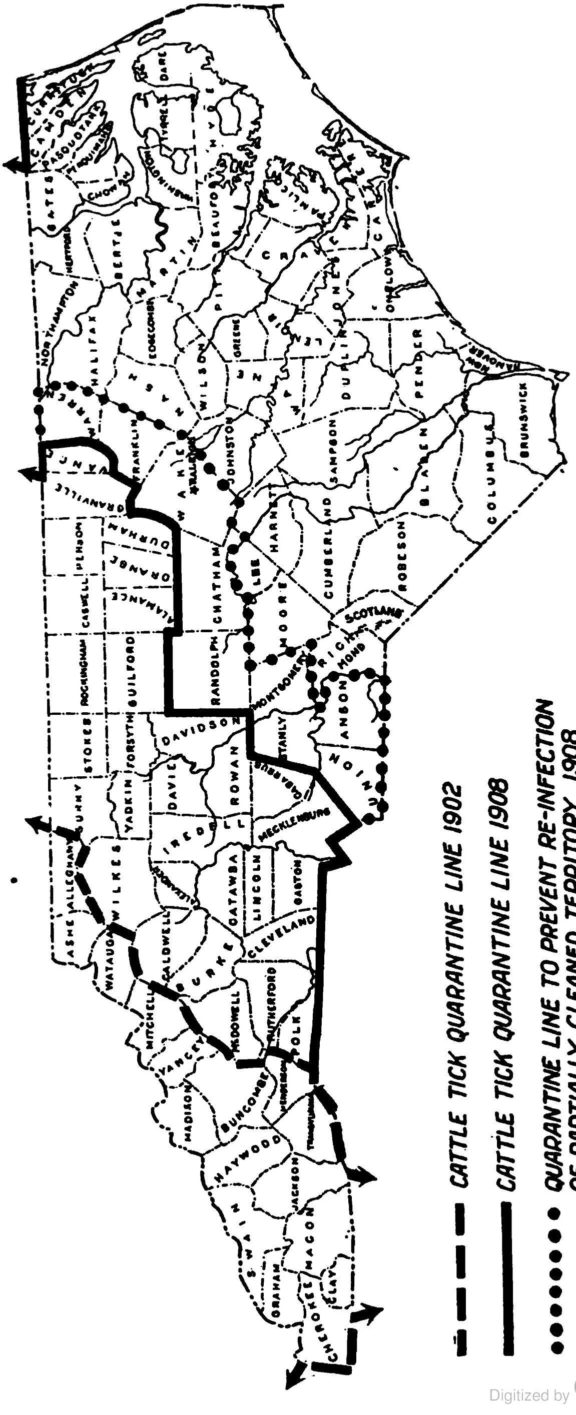
If any of the plans suggested by this general starvation method can be followed it will still be necessary to make certain that the cattle are free of ticks when they are put back onto the clean pastures. Cattle may be cleaned of ticks by a thorough application of Beaumont crude oil, repeated in two weeks; or a thorough application of a mixture consisting of three gallons of cottonseed oil, one gallon of kerosene, one quart of tar, and one pound of sulphur, repeated in two weeks, will kill all the ticks; but these applications must be made to all parts of the skin. Or the cattle may be cleaned of ticks if two lots be provided on which no cattle have been for eight months. Keep the cattle in one lot for eighteen or twenty days and then change them to the other lot for the same length of time. By this plan the cattle will almost certainly be cleaned if the weather be warm; but if it be cold, failure may sometimes occur, and it has the further objectionable features that it requires forty days and that feed must be provided during that period.

The second general method of tick eradication is based on the fact that if some substance be applied to the cattle that will kill the ticks on them no mature ticks can drop in the pasture, and if this be kept up for a sufficient length of time the pasture must become tick-free.

Beaumont crude oil is probably the best substance to apply to the cattle, but it is doubtful if even this can be applied as often as necessary for a sufficient length of time to eradicate the ticks in the pasture without slight injury to the cattle. The most favorable times to use this method is to begin September 1st or April 1st and continue as often and as long as necessary to kill all the ticks that get on the cattle.

The objections to this method are that no substance is yet known that, when applied sufficiently often and for a sufficient length of time to insure the destruction of all the ticks in the pasture, is entirely harmless to the cattle; that the cost of materials and labor is too great; and that unless considerable expense is incurred in providing dipping or spraying apparatus the applications will not usually be thorough enough to obtain success. The pastures, however, may be cleaned in this way, and where conditions warrant, its use is advised, but many failures will occur when cattle-owners attempt the use of this method. The work is not usually done with sufficient care and regularity to insure success.

By 1906 it had been demonstrated that the complete eradication of the cattle tick was practicable, and in a measure this work passed


CATTLE TICK QUARANTINE LINE 1902
CATTLE TICK QUARANTINE LINE 1908
QUARANTINE LINE TO PREVENT RE-INFECTION OF PARTIALLY CLEANED TERRITORY 1908
CURRITUCK
CAMDEN
PASQUOTANK
PERQUIMANS
GATES
CHOWAN
DARE
TYRRELL
WASHINGTON
HYDE
BEAUFORT
MARTIN
BERTIE
HERTFORD
NORTHAMPTON
HALIFAX
EDGECOMBE
PITT
CRAVEN
PAMLICO
CARTERET
JONES
ONSLOW
LENOIR
GREENE
WILSON
NASH
WARREN
FRANKLIN
WAKE
RALEIGH
JOHNSTON
WAYNE
DUPLIN
PENDER
NEW HANOVER
BRUNSWICK
COLUMBUS
BLADEN
SAMPSON
CUMBERLAND
HARNETT
ROBESON
SCOTLAND
RICHMOND
ANSON
UNION
MOORE
LEE
CHATHAM
RANDOLPH
MONTGOMERY
STANLY
DAVIDSON
ROWAN
CABARRUS
MECKLENBURG
VANCE
GRANVILLE
DURHAM
PERSON
ORANGE
CASWELL
ALAMANCE
ROCKINGHAM
GUILFORD
STOKES
FORSYTH
SURRY
YADKIN
DAVIE
IREDELL
ALLEGHANY
ASHE
WILKES
ALEXANDER
CATAWBA
LINCOLN
GASTON
CLEVELAND
WATAUGA
CALDWELL
BURKE
MITCHELL
YANCEY
MCDOWELL
RUTHERFORD
POLK
HENDERSON
TRANSYLVANIA
MADISON
BUNCOMBE
HAYWOOD
JACKSON
SWAIN
MACON
GRAHAM
CLAY
CHEROKEE

beyond the experimental stage. Since August, 1906, however, the Federal Bureau of Animal Industry, having obtained an appropriation for cooperating with the several State governments, this work has been carried on in cooperation with that Bureau of the Federal government.

During the season of 1907 cooperative experimental work was conducted in the counties of Union and Anson, in which the spraying with an emulsion of 20 per cent crude Beaumont oil every three weeks while the cattle were still running on the infected pastures was used for the eradication of the ticks. This work was begun rather too late in the season and discontinued too early, on account of lack of funds to accomplish the most good, but the results obtained seem to indicate that while this is a more troublesome and expensive means of tick eradication than the method of taking the cattle out of the pastures and allowing the ticks to die of starvation, it can be made successful and is probably advisable when stock owners can not be induced to adopt the more certain, easier and cheaper plan of vacating the infected pastures.

The practical results obtained to date as affecting North Carolina, over and above demonstrating to the world the feasibility of the general proposition of cattle tick extermination, are as follows: Thirty counties, as shown on the accompanying map, have been freed of ticks and all restrictions on the movement of cattle therefrom been removed. This is certainly already worth to the State, in money saved, not less than $50,000 a year. All of which is respectfully submitted.

Yours very truly,

TAIT BUTLER,
Veterinarian.

REPORT OF THE POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1907:

The work in pedigree breeding for egg production has been continued during the past year and satisfactory progress has been made. The feeding of dry feeds from hoppers was started the first of the year, and while we have not had a long enough experience with it to say positively that it is better than the wet mash, as far as we have gone with it we are well satisfied with the results. Most of the hens selected from last year's stock for breeders this year have given better egg yields than they did in their first year, and we have hatched a larger percentage of the eggs set this year than ever before, and whether we are right or not we give the change in the manner of feeding the credit for most of the improvement.

A test was made with two lots of barred plymouth rocks of the value of green feed and the results indicate that green feed of some kind is a very valuable addition to the ration, especially where corn is largely used.

A Bulletin on Farm Poultry has been prepared and is now in the printer's hands, and in addition to general poultry information, the results of the experiments carried on during the year are published.

During July and August a number of institutes were attended and talks given on poultry work. In many cases talks were given both at the Men's and Women's Institutes. The interest in most of the counties visited seems to be on the increase, due no doubt to increased price of poultry products and to the campaign that has been started both at the Institutes and in the Farm press in favor of more diversified farming.

The work planned for the coming year includes a study of the principles of heredity, both as to external characteristics and as to prolificacy. The suitability of cottonseed meal for poultry will also be tested both for laying stock and for fattening market stock to determine if it may be profitably and safely fed and in what quantity.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

REPORT OF THE ENTOMOLOGICAL DIVISION.

MR. B. W. KILGORE, *Director.*

DEAR SIR:—I submit the following brief report on the operations of the Entomological Division of the Station for the past year:

As has been pointed out in previous reports, the work of this office has been supported mainly by the State Department of Agriculture and the activities of the office are mainly evidenced by the reports and other publications issued from that Department. However, all questions regarding insects which are addressed to the Station are carefully answered, and each year we are able to do a little original work, either in experimentation or in observation, which is properly Station work.

Your Entomologist was not in the State during the nine months from August, 1905, to June, 1906, but during that time Mr. R. S. Woglum, Acting Entomologist, conducted some careful tests against the San Jose Scale at Raleigh and at Southern Pines, which demonstrated that the substance known as "Scalecide" is quite effective when used of the strength of 1 gallon to 12 gallons of water. As this material is readily mixed with water and is then at once ready for use, it promises to become quite widely used, especially by those who for one reason or another do not wish to attempt the use of the Lime-Sulphur Wash. The past season it was used in several orchards in this State, noticeably those of the Candor Fruit Company at Candor, Montgomery County, where about 33,000 peach trees were treated with every evidence of satisfactory results. Preliminary experiments in the control of the peach and plum Curculio by spraying with Arsenate of Lead in water or in Bordeaux mixture have also been made by Mr. Woglum at Southern Pines with very encouraging results, though it would be very desirable to continue work along this line at some future season. The very severe late freeze of the present season compelled us to abandon that work for this year.

During the month of May Mr. Woglum made several interesting observations upon the Tobacco Flea Beetle in Granville County and proved by experiment that the young plants in the seed bed can be protected from this destructive pest by spraying with Arsenate of Lead and water. The same material may be used for dipping the plants just before they are set out. Both these matters were proven in Mr. Woglum's experiments, but as the time was limited, the tests were not as extended as we should like. The results were very encouraging, nevertheless.

During the past month Mr. Woglum has been working upon some problems concerning cabbage insects, and has made notes on the life history and habits of Cabbage Louse, Harlequin Cabbage Bug and the White Cabbage Butterfly. Although in none of these cases could the work be carried to the final conclusion, his notes will be carefully written up and placed on file in this office.

Very truly yours, FRANKLIN SHERMAN, JR.,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH T UNITED STATES APPROPRIATIONS, 1906-1907

DR.

To receipts from the Treasurer of the United States, as per appropriations for fiscal year ending June 30, 1907, under Acts of Congress, approved Marc 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	7,000.00

CR.

	Hatch Fund.	*Adams F*
By salaries	$7,708.65	$4,433
Labor	1,650.86	522
Publications	1,047.44	.....
Postage and stationery	449.09	57
Freight and express	59.47	88
Heat, light, water and power	136.86	48
Chemical supplies	....	97
Seeds, plants and sundry supplies	592.10	163
Fertilizers	224.88	125
Feeding stuffs	362.34	72
Library	9.50	303
Tools, implements and machinery	481.76	190.
Furniture and fixtures	619.36	......
Scientific apparatus	....	747.
Live stock	655.00	......
Traveling expenses	290.34	148.
Contingent expenses	15.00	......
Buildings and land	697.35	......
Total	$15,000.00	$7,000.

We, the undersigned, duly appointed auditors of the corporation, do here certify that we have examined the books and accounts of the North Caroli Experiment Station for the fiscal year ending June 30, 1907; that we have fou the same well kept and classified as above, and that the receipts for the year fro the Treasurer of the United States are shown to have been $22,000, and the c responding disbursements $22,000; for all of which proper vouchers are on file a have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purpos set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)

N. B. BROUGHTON,
C. W. GOLD,
B. W. KILGORE,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

SCIENTIFIC PAPERS.

THE SPRAYING OF IRISH POTATOES.

By F. L. STEVENS

Experiments have been conducted during the year upon the plantation of D. M. Stanton, of LaGrange, N. C., for the purpose of determining: 1st, whether spraying potatoes for fungous diseases will pay in the eastern section of North Carolina as it does in many other portions of the United States; 2d, to determine which is the better spraying mixture for potatoes in this locality, the ordinary lime Bordeaux or the soda Bordeaux.

The field selected for experiment lay about one and one-half miles southeast of LaGrange, in a region of sandy loam. It was planted to Boone potatoes.

The region devoted to the experiment was selected on account of uniformity of character of soil and lay of the land.

Two rows were left untreated between each experimental plat to obviate any errors which might arise from the spray of one treatment lapping over onto the rows receiving a different treatment. To guard so far as possible against the unfavorable influence arising from the close proximity of diseased plants, the experiment was made on blocks of three rows.

It was the original intention to leave three rows without Paris Green, but it became evident from the inroads of the bugs that such a course would mean the total loss of the crop on these rows, and since the experiment was a co-operative one with Mr. Stanton, such a plan was abandoned.

The following sprayings were made:

1st. May 5.

After the first spraying much mixture was washed off by rain.

2d. May 11.

3d. May 22.

4th. June 1.

The fourth spraying was followed by rain which washed off much of the mixture.

5th. June 20.

The season was throughout unfavorable to potatoes, and Mr. Stanton wrote on May 22, "Tops are making slow growth and I see no prospect of over one-half crop even if good rains should come in the next few days and continue until the end of the season." On May 25 he wrote, "The potato crop is ruined by the drought. * * * We can not get a fair test of spraying this year." On June 6 he wrote, "The vines of the rows sprayed are much greener and better looking than on the unsprayed rows." On June 11 he also wrote, "The vines are looking greener and better than those not sprayed." On June 20, my assistant, J. C. Temple, applied the fifth spraying and wrote, "The leaves were greener and were but little affected with the blight, which is getting bad on the unsprayed rows."

Upon digging, on June 30, the following yields were harvested:

	Gross.	Prime.	Second.	Culls.
Soda Bordeaux	335 lbs.	Not recorded.	Not determined.	
Lime Bordeaux	416.5 lbs.	126 lbs.	152.5 lbs.	138
Paris Green and no Bordeaux	353.5 lbs.	100.5 lbs.	117	136

or a gross gain in the yield by the use of the lime Bordeaux mixture of 17.84 per cent in marketable potatoes, a gain of 25.37 per cent of first grade, 30.34 per cent seconds, and 1.44 per cent thirds.

No. 1 sold on an average at $2.25; No. 2 at $1.80; and No. 3 at $0.80 f. o. b., making a cash gain of $26.05 per acre, based on a yield of 75 barrels per acre on unsprayed fields, or a gain of 22.5 per cent.

The cost of the five sprayings, which resulted in this gain, was about $5.00 per acre, making a net gain from spraying with the Bordeaux mixture, under the condition of this experiment, $21.05 per acre.

Mr. Stanton, under date of September 8, writes, "The test was not a good one, yet it shows that lime Bordeaux pays."

A BACTERIAL DISEASE OF LETTUCE.

BY F. L. STEVENS

Specimens of lettuce badly affected with some disease were collected by J. G. Hall at New Bern and sent into the laboratory on April 4, 1907. The disease showed itself upon the plant, in mild infection, as spots upon the leaf. In early age these spots are less than 1 mm. in diameter and are of a pale, yellowish-green color rather than the normal green of the lettuce leaf. Later they turn slightly straw colored and then brown. When the spots attain the brown condition the tissue is seen to be shrunken in thickness, and upon holding such a leaf to the light the diseased spot seems to be surround by, a border 1 or 2 mm. in diameter, of pale green tissue. The infected spot enlarges and as it does so the chief characteristic of the disease becomes apparent, that is, a shrinking and drying of the diseased tissue, resulting in a membranaceous region, in which the veins appear as a striking net work of dark anastomosing threads. (Fig. 2.)

As the diseased areas upon the leaf enlarge many of them become confluent and large regions of the leaf, one-fourth, one-third or one-half, may blend into one continuous diseased spot, throughout which the character as expressed above appears. That is, upon being held to the light, the diseased region appears transparent, with the thickness of tissue paper, and is set with blackened veins. Viewed by reflected light, as when held in the hand or against some dark object, the thinness of the spot and the conspicuousness of the veins are of course not apparent, and the whole diseased spot appears as a dead, blackened portion of the leaf, somewhat resembling a frosted leaf. The disease sometimes involves all of the leaves of the head.

Upon miscroscopic examination no fungous threads whatever were seen, and every diseased spot, young or old, no matter how small, even a piece of tissue 1 mm. square, upon being torn apart in a drop of water, was seen to give forth myriads of bacteria. These issued in every direction from the affected tissue in such clouds as to be distinctly visible to the naked eye to a distance of 1 to 2 mm. These bacteria were rather long rod forms, which stained easily with Gentian Violet. Bits of healthy tissue teased apart and examined in similar fashion revealed the presence of no bacteria whatever.

Bits of diseased tissue were taken with aseptic precautions, teased and diluted, then plated in nutrient beef agar and in cowpea agar, resulting in each case in a practically pure culture of one species of organism. On standard beef agar the colonies when four days old, at 12° to 17° C., attained a diameter of about 0.7 mm. They were circular, smooth, with convex surface. Under the microscope they were highly refractive, finely granular, often with a small granular core; by transmitted light they were translucent; the color was that of olive oil. In consistency they were soft.

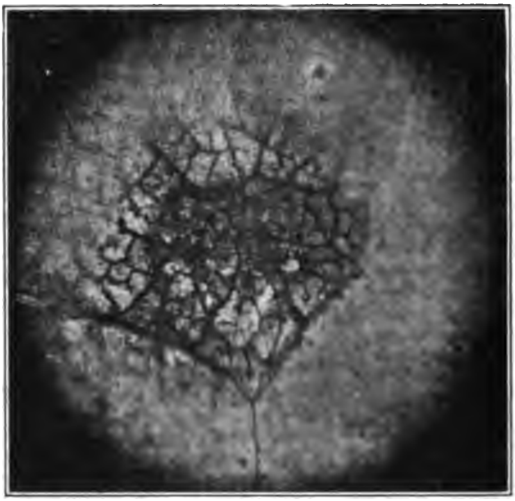


FIG. 2.—A portion of a single spot of the lettuce bacterial disease enlarged, seen by transmitted light showing the extremely transparent nature of the leaves, the veins standing out clearly.

Deep colonies were lenticular to circular, 0.1 mm. in diameter, surface very slightly rough, finely granular, soft.

The streak on beef agar when four days old at room temperature was filiform, convex, smooth, olive-oil colored, translucent, soft.

In broth cultures the fluid was very slightly clouded in three days. There was no membrane, but there was a very fine growth at the surface and a very fine sediment constantly falling. Upon agitation a very fine granular sediment rose from the bottom of the tube.

Several attempts were made to secure inoculations by spraying a liquid culture upon lettuce plants, but the attempts were unsuccessful.

Notwithstanding the failure of securing successful inoculation, the absence of any other causal agent from the diseased spots, the universal appearance of bacteria in practically pure culture, and the general appearance, make it very probable that this disease is caused by bacteria. Indeed it is probably the same disease that was studied by Percival C. Brooks.[1]

This disease was of only slight importance this year, only a few plants being affected. The disease is, however, a serious one to the individual lettuce plant, since an affected plant is entirely devoid of commercial value. If conditions should be such as to admit of the disease gaining a greater foothold in the lettuce beds, it would become of much significance.

---

[1] Mass. Agr. Exp. Station, 19th Annual Report, January, 1907, p. 163.

SCLEROTIA ON CARROTS.

By F. L. STEVENS

Specimens of carrots bearing many small, soft spots were found among carrots exhibited at the Horticultural fair at New Bern, May 22. The spot in each case consisted in its younger condition of a sunken area, somewhat soft, and usually bearing in its center a few strands of white, cotton-like mycelium. Frequently ten or twelve of these spots, from an eighth to a fourth of an inch in diameter, were found on a single root, as shown in Fig. 3. In the older stages of the disease these spots enlarged and the whole rotten area was covered with a dense felt of white mycelium.

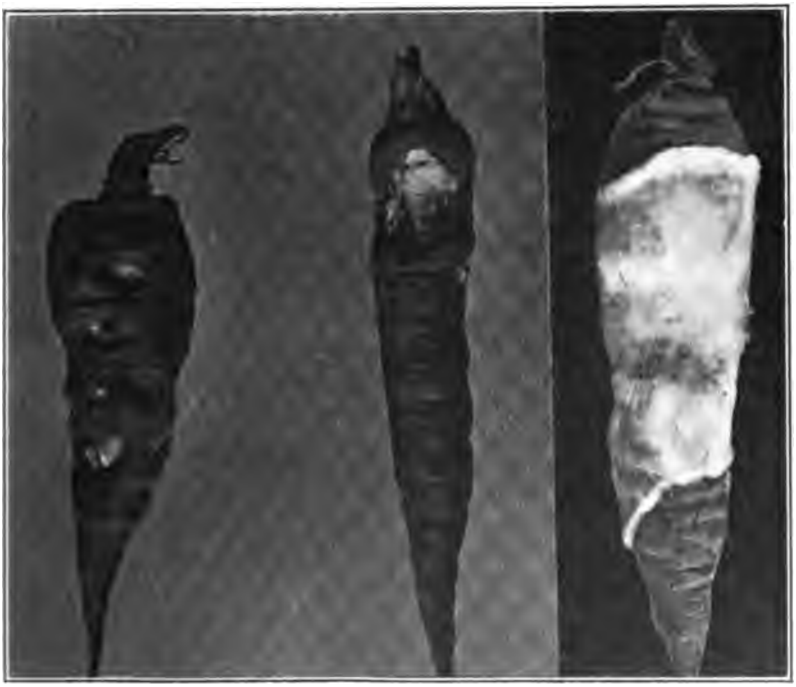


Fig. 3.—Carrots in various stages of decay from the Florida sclerotial disease.

Carrots in an incipient stage of the disease were placed in a moist chamber, and within twenty-four hours there was an exceedingly luxuriant growth of white mycelium extending for an inch or more from the point of original infection. The condition at this time is illustrated in Fig. 3 at the right. A day or two later this mycelium extended so as to envelope the whole root, and grow out over the glass of the dish and into the air. At this time there were many minute centers of denser aggregation of the mycelium These regions rapidly assume a spherical form and a yellowish tint, at the same time exuding drops of water. At a little later period these bodies, sclerotia, become a light brownish color and later almost black. In the yellow stage they closely resemble mustard seeds, both in size and color.

The fungus causing the rot is clearly the same as that collected in Florida on egg plant, tomato and several other plants by Prof. Rolfs, and described later with illustrations by Byron D. Halsted, in report of New Jersey Agricultural Experiment Station, 1903.

The distribution of this fungus, as shown by the U. S. Plant Disease Survey Records, kindly furnished me by Dr. W. A. Orton, of the Bureau of Plant Industry, is as follows:

"On Solanum tuberosum, Lycopersicum esculentum, Phaseolus sp., Cucurbita sp., Daphne odorata, at Lake City, Florida, collected by P. H. Rolfs. On tomato at Boston, Georgia; on cowpea at Auburn, Alabama; and on potato at Hastings, Florida."

In northern climates this fungus is unknown as a parasite, although it grows in the laboratory luxuriantly as a saprophyte. No record has been made of it heretofore so far north as North Carolina, and even in the present instance it may be that the fungus made its attack after the carrots were pulled and that it is here rather saprophytic than parasitic.

THE CHRYSANTHEMUM RAY BLIGHT.

By F. L. STEVENS

The common name chosen for the disease at present under discussion is taken from the most conspicuous symptom of the malady, a blighting of the corolla of the ray flower, resulting in poorly developed, discolored, one-sided heads. (Fig. 4.)

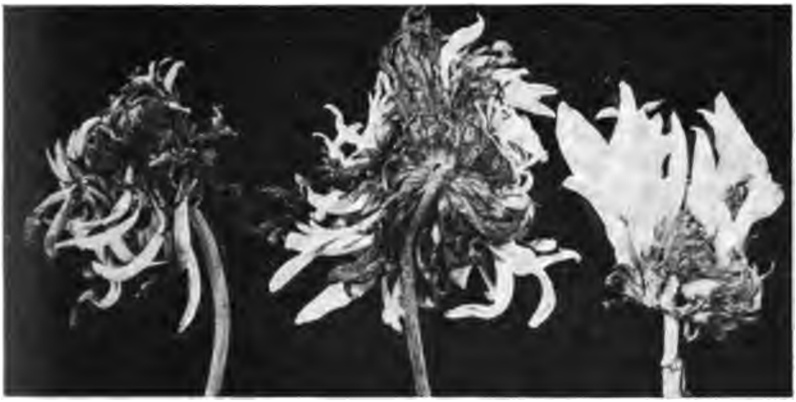


FIG. 4.—Three heads, showing disease as it naturally occurs.

Attention was first called to the disease by a letter from Fayetteville, N. C., dated November 13, 1906, and accompanied by specimens. The disease has been known at that place and has continuously recurred for a period of three years, each year with increasing destructiveness. It was first attributed by the owner of the plants to want of ventilation, but upon its occurrence the second year, the possibility of such a cause was precluded by the conditions. The disease was found upon plants in the open as well as upon those of the greenhouse. The first year it was known it was found only upon late varieties, but during the present year it appeared upon all varieties in the owner's collection, the variety, "Nellie Pockett," being particularly susceptible. The "Golden Wedding," a late yellow variety, always suffers badly in the collection in question. Since receiving specimens from Fayetteville the disease has been found in Raleigh, and it may be of wide occurrence.

SYMPTOMS.—The disease is most conspicuous in the flower clusters which it attacks usually upon one side, either in the bud or during various stages of blooming. The affected blossoms turn straw color or brownish, cease to develop and wither, the discoloration proceeding from base toward tip, on each individual flower, thus distinguishing the disease at once from many disorders which may resemble it superficially. If the case be severe, and the attack be upon a bud while still young, no rays will develop; the head will not open. If the attack be later, a portion of the head, one-half or two-thirds, or more or less, may develop normally and thus by contrast heighten the conspicuousness of the disease. Heads nearly open and apparently healthy may on the following day show one side far progressed in disease. The owner says "it developed so fast that a large, perfect bloom in the morning would be wilted by night."

The receptacle turns black, and the peduncle, to a distance of one to two centimeters below the head may likewise be blackened throughout. Later, shriveling and softening of the peduncle allow the head to nod in a characteristic manner.

On the affected plants, portions of the stem are often blackened to a distance of several centimeters, in a band more or less completely encircling the stem. Frequently this diseased spot is associated with a leaf, the petiole of which also partakes of the discoloration.

Microscopic Examination.—Under the microscope, diseased flowers, rays, corollas, receptacles, peduncles, and the diseased portions of the stem all reveal the presence of a rather coarse, much branchd mycelium, that is easily recognized by its septa, which are numerous and stand out with an especially striking clearness. (Fig. 5.) In the humid region between the flowers, in the head, the mycelium becomes aerial, forming a loose floccose weft, visible to the naked eye. In the hollow pith cavity of the blighted receptacle a similar profuse mycelial development occurs; while on old specimens, in culture dishes pycnidia were also found identical with those which developed in pure cultures, to be described later. Only one fungus was seen and no bacteria whatever were visible.

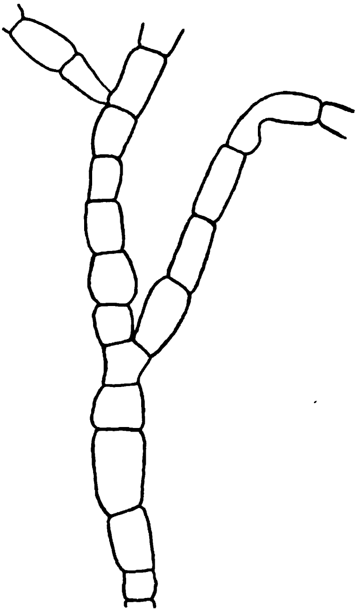


Fig. 5.—Normal Hyphæ, mature, showing septation with slight construction; also the mode of branching.

Isolation.—Diseased ray flowers were removed with sterile forceps and thrown upon solidified pea agar in Petri dishes, several to each dish. Similarly, with aseptic precautions, bits of the wood and bark from diseased peduncles, stems, and from the inside of the receptacle were plated. Each of those cultures, twenty-five or more in number, plated on November 18, resulted within twenty-four hours in pure colonies, all alike, of a fungus with a mycelium identical in appearance with that seen in diseased tissue.

THE FUNGUS.—The colonies grew with remarkable rapidity and remained sterile until five days old. Pycnidia were then found in the oldest portions of a colony upon one of the plates. They were amber color as seen with the two-thirds objective and transmitted light, approaching No. 30 of *Saccardo's Chromotaxia* or the YYO^4 of the *Prang Standard Color Scale.* They were coarsely reticulated on the surface, owing to their composition of woven, coarse, mycelial threads. (Fig. 6.) In diameter they ranged from 102 to 204 Mu. (the most usual size being about 150 Mu.) They were round in outline and elevated from the surface, hemispherical. Grown upon corn and also upon the apple agar, the pycnidia were very much darker, almost black. The ostiolum seemed entirely absent in many pycnidia which developed deep in the culture medium, but was present in all growing upon the surface of artificial media or upon natural substrata. The spores were regular and oblong or quite irregular oblong or swollen and rounded at one end and pointed at the other end. Regular-oblong, however, is the prevailing type, with a pronounced tendency toward irregularity. (Fig. 7.) One septum, more easily seen in stained preparations, is visible in most of the older spores; though young or small spores and many larger and older ones do not show septation. The septum is frequently central, but there is a tendency for it to be located nearer to one end than to the other. Rarely two septa or even three are present in one spore. The spores measure from 3 to 6.2 Mu. in thickness by 10 to 20 Mu. in length; 6.2 Mu. by 18 Mu. being the usual size. The spores are hyaline or of very slightly greenish tint. In mass, as extruded from ripe pycnidia they appear slightly pink. The walls of the spores are evidently mucilaginous since the spores, as they are pushed from the pycnidia upon the absorbtion of water, issue in worm-like coils, in which coils they adhere for considerable time, though they are not in visible contact. The spores germinated rapidly in water (Fig. 8), practically every spore germinating. In germinating the septum appeared in all spores, and 1 to 3 germ tubes protruded from each cell. These tubes rapidly became richly septate, and the protoplasm highly vacuolate.

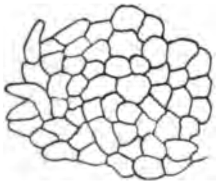


FIG. 6.—Surface view of pycnidum showing reticulation.

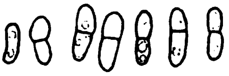


FIG. 7.—Spores from pycnidia grown on cow pea agar

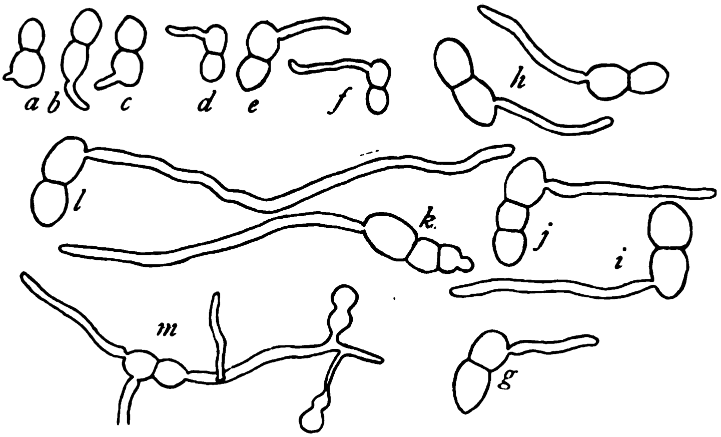
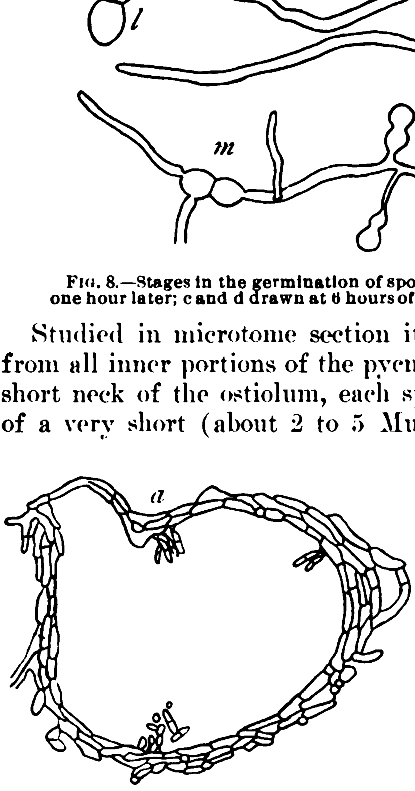


FIG. 8.—Stages in the germination of spores; e and f=c and d respectively, draw one hour later; c and d drawn at 6 hours of age, and e and f at 7 hours; m 15 hours ol

Studied in microtome section it is seen that the spores are from all inner portions of the pycnidial wall (Fig. 9) except the short neck of the ostiolum, each spore originating singly on th of a very short (about 2 to 5 Mu.) stalk (Fig. 10). These s phores are lateral branch the mycelial threads which stitute the pycnidial wall. pycnidium originates withi host tissue, *i. e.*, immersed rapidly enlarges to burst overlying epidermis, so tha mature or even half grown idium appears superficial. is no especial aggregation o celium below the base o pycnidium.



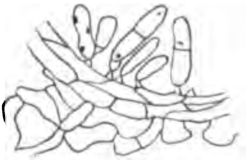


FIG. 9.—Section of pycnidium. a, neck of ostiolum.

FIG. 10.—Portion of pycnidial wall in section showing method of spore attachment.

The pycnidium in very y stages is solid, without ity. Later a spore cavity velops, though apparently more rapidly than is ne tated by spore production. the youngest pycnidia havi spore cavity, the surroun wall is composed of several to eight) layers of mycelium. As the spore cavity becomes diste the wall becomes thinner until at maturity it is composed of only two or three layers of mycelium, while the region of the ostiolu comes one layer thick and eventually ruptures.

This fungus clearly belongs to the section *Hyalodidymæ Sacc.* of the *Sphærioideæ* Sacc. and seems closest in affinity to the members of the genus *Ascochyta.* The possession of a slight beak, which, however, is always very small and often entirely absent, might throw it into the genus *Rhyncophoma* Karst, but members of that genus are typically upon wood, usually saprophytic and have a more pronounced beak.

Since no *Ascochyta* or indeed any other species of the *Sphærioideæ Hyalodidymæ,* which could by any possibility be identified with the species considered in this paper, has come to my notice as growing upon the Chrysanthemum or any of its kin, I regard this as a new species, for which I gave the following description:*

Ascochyta Chrysanthemi Stevens.

Pycnidia; few, immersed, early erumpent, single or scattered, round, hemispherical, amber colored, 100-200 Mu., mostly about 150 Mu.; ostiolum central, small, dark bordered, often raised by a short neck; surface reticulate; pycnidia, on agar media irregular, often with two ostioles and varying much in size, black in color. Mycelium abundant, innate also superficial, aerial, floccose, richly septate.

Spores oblong, straight or irregular, 3 to 6.2 Mu. by 10 to 20 Mu., mostly 6.2 by 10. Ends obtuse or acute; septum usually one, often obscure, rarely 2 or 3, usually without constriction until germination; protoplasm vacuolate, hyaline or light pink in mass.

Habitat; in corollas, heads, petioles and stems of cultivated plants of Chrysanthemum Indicum, causing blight. North Carolina.

CULTURE CHARACTERISTICS OF THE FUNGUS.

Thermal Relation.—Cultures in Petri dishes on cowpea agar were inoculated December 8, '06, and placed in darkness at three temperatures with the results appearing in the adjoining table.

Table I.—Inoculated December 8, Growth in mm.

Plate Number	Place	Days of Month—December											Daily Average
		9	10	11	12	13	14	15	16	17	18	19	
	Temp. min. ---	--	--	12	12	18	17	18	--	12	--	11	16
	Temp. max. ---	--	--	20	20	21	21	20	--	18	--	17	19
1	Room ----	2	4	--	12	15	18	22	25	26	33	39	3.5
2		2	3	--	12	15	18	22	25	26	33	39	
	Temp. 30 to 35.												
35	Incubator --	3	3	--	Con	tam	i	nat	ed.	--	--	--	2.2
36		3	3	--	?	?	--	8	11	15	22	25	
	Temp. min. ---	3	10	1	3	1	6	9	10	--	14	--	6.3
	Temp. max. ---	17	18	14	7	16	21	22	21	22	14	--	17.2
37	Outdoors --	0	2	--	?	--	--	7	11	14	19	22	2.
38		0	2	--	--	--	--	7	11	14	19	22	

---

* Botanical Gazette, Vol. 44, October, 1907, p. 241.

The growth both outdoors in the cold, and in the incubator, was exceedingly irregular, stunted or slow, while that of room temperature was very much more rapid.

In addition to being an unfavorable temperature for growth, the heat of the incubator produced great irregularity in the zonal development; threads started vigorously, stopped suddenly, and growth began in another direction, so that all regularity of zone formation was lost. Much of the mycelium also became encased in a dark coat, as described under the effect of cowpea leaf agar below. The plates kept at outdoor temperature, while they maintained a fair regularity in the formation of zones, did not make the same number of zones as the cultures kept at room temperature. The number of zones made in the room temperature being six, while that outdoors was four.

Acid Relation.—Cultures in lettuce agar in dark at room temperature in various degrees of acidity gave the following record:

Table II.—Inoculated December 13, Growth in mm.

Plate	Drops of Normal Acid or Alkali Per Tube	Fuller's Scale	Inoculated.	Day of Month—December						Average Per Day
				14	15	16	17	18	19	
25	10	+40	12-13	?	0	0	--	--	--	----
27	5	+20	12-13	?	0	0	--	--	--	----
49	0	0	12-13	2	3	7	12	15	18	3.1
31	5	—19	12-13	gr.	3	5	11	14	16	2.6
29	10	—39	12-13	?	2	3	8	9	10	1.6
34	15	—59	12-13	?	0	0	2	3	4	.7
33	20	—99	12-13	?	0	0	gr.	5	6	1.

It is clearly seen from these data that a neutral medium, or one only slightly alkali, favors best the growth of this fungus.

In the plates bearing 10, 15 and 20 drops of normal alkali there was no formation of zones at all. In the plate bearing five drops of alkali two zones were formed.

The effect or lack of effect of light upon rapidity of growth is exhibited in the following table; cultures grown at room temperature on cowpea agar:

Culture Kept in Light and in Darkness, Inoculated December 8, Growth in mm.

Plate		Inoculated	Day of Month—December										Average Per Day
			9	10	11	12	13	14	15	16	17	18	
1	Light ___	12-8	2	3	5	12	15	18	25	26	33	39	3.9
2			2	3	5	12	15	18	25	26	33	39	3.9
3	Dark ____	12-8	2	3	5	13	14	18	22	25	31	37	3.7
4			2	3	5	12	14	18	22	25	31	36	3.6

The cultures in light and dark agreed almost absolutely in rapidity of growth, a slight difference of one or two mm. noted at the end of ten days growth, being so small as to be insignificant.

Growth in Various Media.—Cultures in agar with various nutrients at room temperature in the dark grew as follows:

Inoculated December 13, 1906, Growth in mm.

Plate	Medium	Inoculated.	Day of Month—December. 14	15	16	17	18	20	21	Jan.12
	Temp. min.		17	18	--	12	--	--	--	
	Temp. max.		21	20	--	18	--	--	--	
9	Pure agar	12-13	Grew	4	6	11	----	----	----	65
10				4	7	11	14	----	----	70
7	Pea agar	12-13	Grew	4	6	10	13	----	----	18
8				4	6	10	14	----	----	18
15	1% Peptone agar	12-13	Grew	3	5	9	9	----	----	70
16				4	7	10	11	----	----	70
11	1% Glucose agar	12-13	Grew	5	9	15	1	----	----	80
12				5	8	13	17	----	----	80
13	5% Glucose agar	12-13	Grew	6	11	16	21	----	----	70
14				6	11	16	21	----	----	75
17	1 % Starch agar	12-13	Grew	4	6	10	11	--	----	------
18				4	7	11	12	----	----	------
	Date	12-8	9	10	11	12	13	14	15	Jan.12
	Temp. min.				12	12	18	17	18	
	Temp. max.				20	20	21	21	20	
5	Standard beef agar	12-8	1.5	2	5	9	10	11	15	52
6	Cowpea agar		1.5	2	5	10	12	13	17	
3	Standard beef agar	12-8	2	3	5	12	14	18	25	32
4			2	3	5	12	14	18	25	
39	Standard beef gelatine	12-8	2	2	4	6	8	11	17	35
40			2	2	4	6	10	12	17	

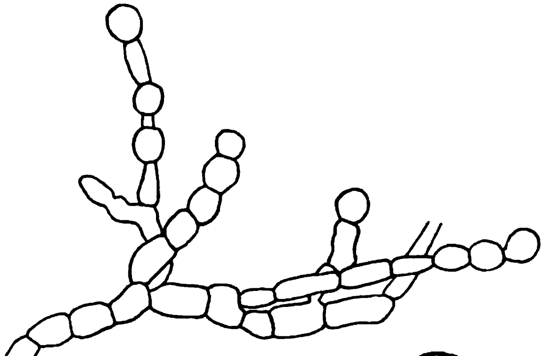
Colonies grown in *pure agar* and those upon pea agar were of the same general appearance, thin, colorless, and structureless; zone formation being entirely absent. A very few pycnidia were produced. By increasing the richness of the pea agar to 4 per cent pycnidia were secured, but without change in other characters. The growth in pea agar was no more rapid than that on pure agar, but was much more dense; the mycelium was colorless and very few pycnidia developed.

One per cent *peptone* adds nothing to the nutrient value of the medium for this fungus. Growth comes to an end earlier than in pure agar or other media and there are no pycnidia, no color to the mycelium, and only a very slight indication of zonation.

Glucose.—Two and 5 per cent favor growth, the 5 per cent being slightly better than the 2 per cent. No pycnidia developed, but there is marked though irregular zonation, and the whole mycelium develops a striking, intense blackness. The septation and cell contents are normal and the color rests with the cell wall.

Starch.—One per cent did not increase the rate of growth, although upon microscopic examination it was clear that the starch grains were digested almost as soon as the advancing threads of the fungus reached them, and growth continued long in these plates. The effect of starch upon the general appearance of the colony and upon the mycelium was precisely as in the glucose plates.

In *Standard beef agar* and *gelatine* growth was about as with peptone agar, though it continued for a longer time. The mycelium was of abnormal, irregular character (Fig. 11) and there were no pycnidia nor any development of color nor of well marked zones.



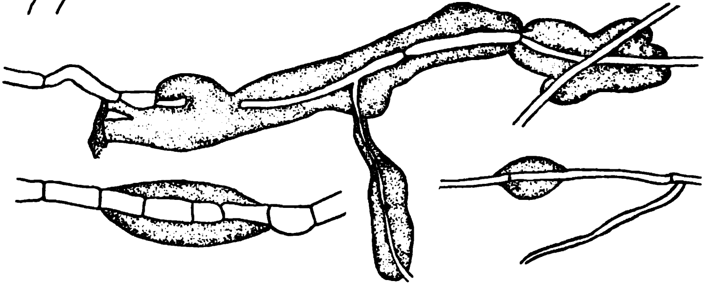


FIG. 11.—Abnormal hyphæ, mature, as grown in gelatine, the cells being unusually swollen.

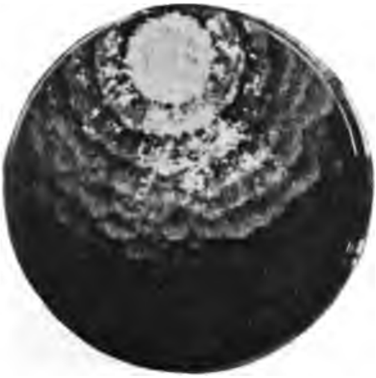
FIG. 12.—Thickening of hyphæ, produced by too high temperature or an excess of nitrogenous food.

On *beef gelatine* the growth was more uniform than on beef agar, and the zones were somewhat clearly marked, liquifaction following in the wake of the mycelium, lagging about four or five mm. behind the mycelial tips.

In *litmus-lactose agar* the colonies developed as on beef agar without acidity.

Upon *cowpea leaf agar* the growth while exactly parallel in rapidity with the growth upon the cowpea agar, exhibited remarkable differences in the structure of the colony, the number of zones being much less and consequently of much greater breadth. The mycelium also clung closer to the medium, was less floccose and less aerial, and in the older region of the mycelium the cells became extraordinarily thick and short and assumed a dark color. In some instances the protoplasm within the cell rounded off and became invested by a thick brown coat. In other instances a similar brown coat of much greater thickness, often four or five times as thick as the diameter of the mycelium, would form around the mycelial threads. (Figs. 12 and 13.)

Cowpea agar proved the best medium for the growth of the fungus, the concentric zones forming with great regularity, five dense zones and six lesser zones being formed in a period of eleven days. In the older central portion pycnidia began to form at the end of about eight days, though often later. Pycnidial formation proceeds from the central zones to the younger zones, the pycnidia being most numerous in the denser zones, although they were by no means lacking in the lesser zones.



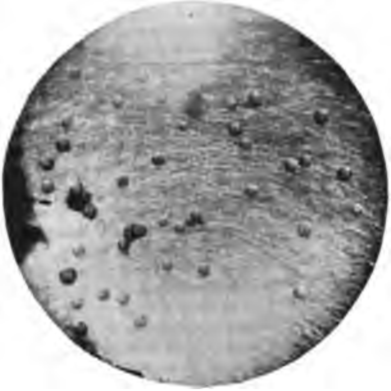


Fig. 13.—Pure culture of the fungus seventeen days old, grown upon cow-pea agar in diffuse light; pycnidia not then formed.
Fig. 14.—Pycnidia on agar plate, viewed from below.

Upon *boiled rice,* in test tubes, the fungus grew luxuriantly. As the threads first invaded the rice there was developed a salmon color, which later turned to black.

Upon *boiled corn,* in test tubes, the mycelium developed well, became black, and pycnidia were present in abundance at the end of eleven days.

The most striking features noted in these nutrition studies was the influence of starch and glucose in agar or the starch of the rice or corn media in causing the development of an intense black coloration in the mycelium. Also the unfavorable influence of peptone, beef and gelatine as evidenced by distorted mycelium and the failure to develop pycnidia.

The *formation of zones* is the most characteristic feature of growth of this fungus upon clear, solid media. (Fig. 14.) Reference has constantly been made to this feature. The lesser zone, the zone which immediately surrounds the point of inoculation, is due to the mycelium rapidly growing out in every direction in the medium from the point of inoculation. As each individual thread becomes more and more distant from the center and has made more and more branches, the threads begin to crowd each other much more closely until, if conditions be proper, a time is reached when apparently the crowding becomes so great that further growth in length is inhibited. There then occurs a development of aerial hyphæ and a thickening and darkening of the ends of hyphæ already produced; this resulting in a darker zone surrounding the lighter zone. After maintaining this condition for some time, individual threads, in a scattered fashion, break through the outer dense zone, continue their growth and proceed to the formation of a second lesser zone, followed in course of time by a second denser zone, all being formed in precisely the same fashion that the first two zones were made. Plates have been exposed under different light relations and different temperatures, and it seems probable that there is no connection between either of these factors and formation of zones in this fungus, other than is occasioned by increasing or decreasing growth.

INOCULATIONS. (Figs. 15, 16 and 17.)

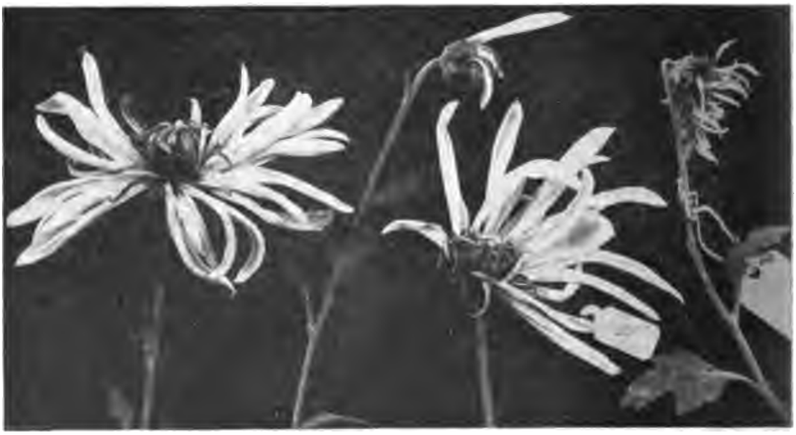
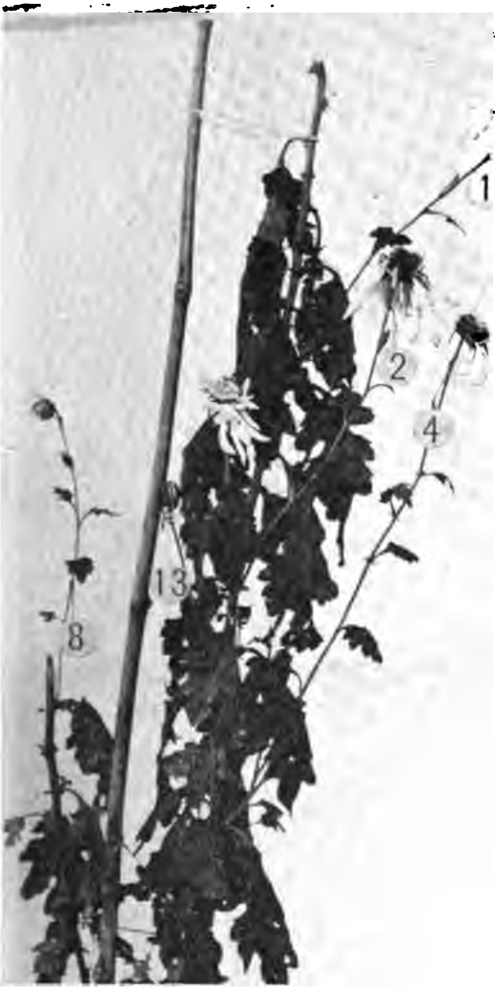
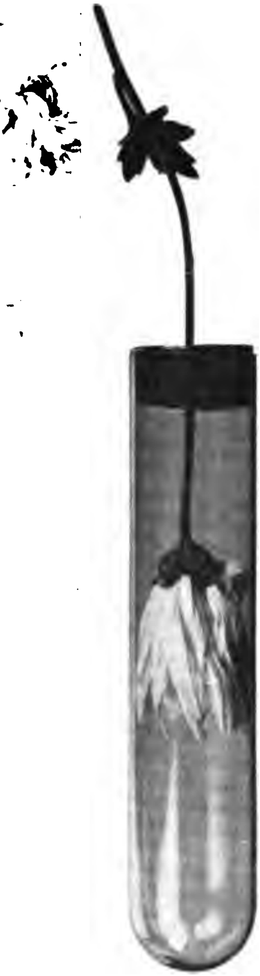


FIG. 15. Four diseased heads produced by inoculation from pure culture.

Some forty inoculations were made with mycelium taken from pure cultures on bits of agar. Of these twenty-eight gave positive results. Control cultures remained uninfected. Inoculations were made within the involucral scales, between the flowers in the head, on stems, and on leaves, as follows:





IG. 16.—Showing method of covering inoculated heads to supply humid atmosphere.

Fig. 17.—Plant bearing flowers in condition of disease; produced by inoculation: 1, The topmost head inoculated between the flowers with pycnidia from agar. 2, The second tallest head as in No. 1. 4, Inoculated on scarified bark immediately below the head. Dates as above. 13, Inoculated November 29 inside involucre, covered by tube twenty-four hours; diseased December 8. 8, Inoculated November 24 with agar on scarified bark under wet cotton; diseased December 10.

SERIES I.

Inoculated from mycelium obtained from the original agar plate culture on which diseased rays had been placed. Inoculations made November 22, 1906.

Inoculation No. 1—under the involucre of the bud, which was just beginning to open. Observed December 8, growth; December 18, exhibited typical disease.

Inoculation No. 2—in the axil of the uppermost bract, in needle pricks, with agar. The bud above was just beginning to open. Examined on December 8 and December 18 with no indication of disease.

Inoculation No. 3—with mycelium upon agar upon the end of the unopened bud. Examined December 8, no growth; examined December 18. Typical disease.

Inoculation No. 4—control cultures similar to No. 3, with sterile needle. Examined December 8 and December 18. No growth.

Inoculation No. 5—at base of leaf; the tissue unbroken. Examined December 8 and December 18. No result.

Inoculation No. 6—agar laid upon the outside of the involucre; tissue uninjured. Examined December 8 and December 18. No result.

Inoculation No. 8—same as in No. 6. Same results.

Inoculation No. 9—at the base of the petiole. Tissue uninjured. Examined December 8 and December 18. No result.

Inoculation No. 10—leaf base pricked and inoculated with agar culture. Examined December 8 and December 18. No result.

It is to be noted that in this series Nos. 1 and 3 produced typical disease; that is, all of the inoculations which were attempted within the involucre. Control inoculations produced no growth and attempts to produce the disease upon leaves and stems through uninjured tissue failed.

SERIES II.

Inoculated November 24, 1906, with mycelium, which was richly set with pycnidia.

Inoculation No. 11—agar bearing mycelium placed deep between the petals of the open flower. Examined December 8. Showed typical disease.

Inoculation No. 12—same as No. 11.

Inoculation No. 13—same as No. 11, using sterile agar; control inoculation. Examined December 8 and December 18. No growth.

Inoculation No. 14—peduncle immediately below the bud scarified. Inoculated with mycelium on agar. Examined December 8. Showed typical disease.

Inoculation No. 15—similar to No. 14, but with sterile agar. Control experiment. Examined December 8 and December 18. No growth.

Inoculation No. 16—upon scarified stem immediately under head with agar bearing mycelium, the whole covered with wet cotton. Examined December 8 and December 18. No result.

Inoculation No. 17—conditions same as in 16. Examined December 18; head typically diseased.

Inoculation No. 18—conditions same as in 16. Examined December 8, no result; examined December 10, typical disease.

Inoculation No. 19—agar bearing mycelium placed upon the tip of the opening head. Examined December 8, no growth; December 18, typical disease.

Inoculation No. 20—conditions same as in No. 19. Examined December 8; typical disease.

Inoculation No. 21—condition same as in 19; lost through accident.

It is to be observed that in this series the inoculations within the flower produced typical disease. Control inoculations produced no disease. Inoculation upon scarified stem when covered with damp cotton to prevent evaporation was capable of inducing the disease.

SERIES III.

Inoculated November 29, 1906.

Inoculation No. 22—agar bearing mycelium was placed between the rays of a head and the whole covered with a tube and supplied with wet cotton to prevent evaporation; tube and cotton were removed the next day. Examined December 8, showed typical disease.

Inoculation No. 23—similar to 22, but inoculations made just inside the involucre. Examined December 8 showed typical disease.

Inoculation No. 24—similar to 22, but upon the tip of the bud. Covering tube removed after two days. Examined December 8 showed typical disease.

Inoculation No. 25—a single ray from a diseased flower was placed among the rays of a flower just beginning to open. They were left uncovered. Examination December 8 showed typical disease.

Inoculation No. 26—similar to 25. Covered with tube as in 22. Examination December 8 showed typical disease.

Inoculation No. 27—similar to 22. Examination December 8 showed typical disease.

From inoculations Nos. 22, 23, 24 and 27 it seems evident that the protecting of the inoculations for 24 or 48 hours from evaporation leads to greater certainty and rapidity of infection. Inoculations Nos. 25 and 26 go to show the lack of necessity for any covering when diseased rays are used with which to inoculate. It is possible that the mycelium is in a more vigorous condition in such diseased rays.

SERIES IV.

Inoculations made November 30, 1906, from very vigorously growing mycelium from a plate of cowpea agar.

Inoculations 28 to 31—made from the extreme tip of the mycelium taken from the edge of the colony. Inoculation made under the outer rays. Examination December 8, no growth; examination December 18, all show typical disease.

Inoculations 32 to 35—inoculating material taken from the youngest dense zone in the colony. Inoculated as in 28 to 31. Examination made December 8, no growth; examination December 18, all typically diseased.

Inoculations 36 to 40—inoculating material taken from the center of the colony. The agar being full of old dark, thick hyphæ. Examined December 8, all showed typical cases of disease.

It seems apparent from this series that the mycelium from the older central portions is capable of producing quicker infection than that from the outer region of the colony.

RECOVERY OF FUNGUS FROM INOCULATED HEADS.

In many cases rays were taken from the heads which were made diseased by inoculations, and these rays were thrown upon Petri dishes containing solidified pea agar, with the result that in each case the petal was soon the center of a pure colony of the fungus identical with that used in the inoculation.

As the result of all of these inoculations it seems clear that the fungus in question is actually the cause of the diseased condition of the blossom; that it can gain entrance to the tissue of the blossom much more easily than to the tissue of the leaves, petioles and stems, and that humidity at the time of inoculation favors the success of the inoculations.

I desire to acknowledge my indebtedness to J. G. Hall, Assistant Pathologist, for the illustrations accompanying this article.

MEDIA USED.

Cowpea Agar.—Five hundred grams of fresh cowpea pods and contents were stewed in one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Cowpea Leaf Agar.—Five hundred grams of cowpea leaves and petioles were stewed in one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Pea Agar.—Ten garden peas were autoclaved with one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Four Per Cent Pea Agar.—Four per cent by weight of dry peas were stewed with one litre of water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Standard Beef Agar.—According to the rules of the American Public Health Association.

Standard Beef Gelatine.—According to the rules of the American Public Health Association.

Pure Agar.—Agar without addition of nutrients, 1 per cent agar to one litre of water.

Litmus-lactose Agar.—Standard beef agar with the addition of 1 per cent lactose and litmus sufficient to color.

Lettuce Agar.—Ten grams of lettuce leaves and petioles were stewed in water for one-half hour, drained, 1 per cent agar added, autoclaved at 110° C. and filtered.

Boiled Rice.—Two grams of washed rice to 8 cc. of water, tubed, autoclaved at 110° C.

Boiled Corn.—Two grams of washed corn to 8 cc. of water, tubed, autoclaved at 110° C.

Glucose Agar and Starch Agar.—Made by adding percentages indicated to pure agar and sterilizing intermittently.

Peptone Agar.—By adding per cent indicated to pure agar and autoclaving at 110° C.

THE EFFICIENCY OF PURE CULTURE INOCULATION FOR LEGUMES.

BY F. L. STEVENS AND J. C. TEMPLE.

HISTORICAL.

The knowledge that legumes enrich soil is very old, and many references to that power occur in ancient writings. Pliny[1] and Varro[2] both refer to this fact. Root tubercules are said to have been seen as early as 1586.[3] They were described by Malpighi[4] in 1687, yet that this enrichment is dependént upon the presence of the tubercle upon the roots was first made evident by the classical experiments of Hellriegel and Wilfarth about 1886.[5] The conclusions of these pioneers were completely verified by many other workers between 1888 and 1895. Bacteria were first seen in legume root tubercles in 1866 by Woronin.[6] Experiments by Hellriegel[5] in 1886 also proved that the tubercles can not develop in sterile soil, but that if an infusion from a soil in which peas have previously grown be added to sterilized soil, the tubercle will then develop normally. Ward[7] later saw bacteria enter the root hairs and root tubercles develop at this point of infection. In 1888 Beyerinck[8] isolated and cultivated the root tubercle organism upon artificial media. In 1890 Prazmowski,[9] and since then many other experimenters have produced the nodules by laboratory inoculations with pure culture of the root tubercle organism. Since it was definitely shown that the tubercles are due to bacteria, and that the value of the legume crop is dependent upon these tubercles, it has been the constant aim of bacteriologists to devise some successful means of inoculating the germ into field soils that are in such need.

---

[1] A very complete historical resumé of this question may be found in Cent. f. Bak. Par. u. Inf. II, 18 289, by Dr. Gino de'Rossi.

[1] Historia naturalis, LVIII.

[2] De re rustica, I. 23.

[3] Delechamps, Historia generalis plantarum.

[4] Opera omnia. Anatomia Plantarum. Pars II. De gallis.

[5] Hellriegel Welche Stickstoffquellen stehen der Pflanzen. zu. Gebote (Tageblatt der 59, Vers. d. Nat u. Aerzte in Berlin, 1886,) and Hellriegel and Wilfarth. Untersuchungen über die Stickstoffnahrung der Gramineen und Leguminosen (Beilageheft zu der Zeit. des Vereins für Rubenzuckerindustrie des Deutschen Reiches.) Berlin, 1888.

[6] Mem. d. P. Acad. dup. d. Sciences, St. Petersburg VII, 1866, 2.

[7] Phil. Trans. Roy. Soc. London 178, 1887.

[8] die Bakterien der Papilionaceenknollchen. Bot. Zeit., 1888.

[9] Landw. Versuchst. 1890, 37 161.

FIELD INOCULATIONS.

Many successful field inoculations have been made into soil deficient in root tubercle bacteria. Salfeld[1] in Germany in 1887, Fruwirth[2] of Germany in 1893, Schniftes[3] of Germany in 1894, Otis[4] of Kansas in 1898, Duggar[5] of Alabama in 1897, made inoculations by using for such purpose soil that had previously produced good crops of legumes.

OBJECTIONS TO SOIL AS MEDIUM FOR INOCULATION.

The efficiency of soil in which appropriate legumes have grown as a medium for inoculation is unquestioned. It possesses, however, certain disadvantages.

1. It is heavy and cumbersome and therefore expensive to transport to any distance in quantity sufficient for extensive use.
2. Unless due care be exercised there is danger of transporting at the same time seeds of noxious weeds; particularly is this true in the case of clovers or alfalfa, which may be infested with dodder.
3. There is great danger, especially in the Southern States, of carrying infective material of some of the many serious, invincible soil diseases, such as the wilts of cotton, cowpea, tobacco or melons. There is danger of conveying nematodes, which cause the root knot on so many crops in Southern soils.

WHEN INOCULATION IS NECESSARY OR DESIRABLE.

Extravagant claims have been made by some who are interested in selling material with which to inoculate. Soil inoculation is by no means always necessary or even beneficial. Inoculation is desirable and highly beneficial when the germ appropriate to the crop plant is absent from the soil, e. g., in regions where alfalfa has not been grown, it is often necessary to inoculate with alfalfa soil in order to secure tubercles and a good yield. Similarly where cowpeas have not been grown, cowpea soil can be used to advantage. Where cowpeas or alfalfa now grow successfully or in a region where they will grow successfully with tubercles in plenty upon their roots, inoculation is unnecessary.

The advisability of inoculation is indicated in the case of any leguminous crop, where the crop in question fails to produce tubercles properly upon any given field.

---

[1] Storer's Agriculture II., 1897, 105.

[2] Deut. Landw. Presse XVIII, 127, cited by Chester Bull, 98 Pa. Dept. of Agriculture, 1902.

[3] Cited by Chester.

[4] The Industrialist, Kan. Ag. Col., 24, 1898, 363.

[5] Ala. Exp. Station Bull., 76.

INOCULATION BY PURE CULTURES.

As stated above, pure cultures have been many times used in laboratory inoculations, and repeated attempts have been made to extend their use to the field. Nobbe and Hiltner, in 1896, prepared pure cultures of the root tubercle organisms, which were placed on sale under the commercial name of Nitragin. This substance was extensively tried in Germany and America. In many instances there was marked benefit from its use, and in many other cases no benefit resulted. The frequent failure to benefit may be partially attributed to the use of Nitragin on soils already well inoculated, and therefore not in need of inoculation. In part, also, it was probably due to a variation in vigor or vitality of the cultures. Probably many cultures when used were no longer alive. In any event, Nitragin fell into disuse.

Another attempt to attain the ideal distribution of pure cultures of the root tubercle organism in form suitable for practical field inoculation, was made by workers in the United States Department of Agriculture, and the goal was thought to have been reached. It was claimed that not only were these workers able to cultivate the organism (as many had done before), but that they were able by special methods to increase its nitrogen gathering efficiency, and further, that they were able to successfully distribute their cultures of bacteria, of heightened virulence, in dry form upon cotton so as to be of practical use to the farmer. The claims seem to have been prematurely set forth, possibly hastened by an unfortunate magazine or newspaper notoriety. Results have shown that notwithstanding the frequent success in the use of such cultures they can not be depended upon with such certainty as to warrant their general use, and this method of distributing the germ has been discontinued by the Bureau originally issuing the cultures and another substituted in its stead.

THE METHOD OF LIQUID CULTURES.

The present method of the United States Department of Agriculture consists in the issuance of cultures in liquid, hermetically sealed in glass. With the history of inefficiency and unreliability of the method of distribution of cultures in dried form upon cotton in mind, it was deemed wise to make a test of the present method. To this end cultures were received through the courtesy of the National Bureau of Plant Industry. These cultures were received in May, 1906, and the labels indicated that the alfalfa, vetch, Canada field pea and red clover were to be used before July 1st, the sweet pea and bean before July 15th. None were marked with earlier dates of limit of utility.

VIABILITY OF THE LIQUID CULTURES.

In order to ascertain the approximate number of living bacteria in the liquid cultures of bean, cowpea, Canada field pea, sweet pea, red clover and vetch, the cultures were opened with precautions to avoid contamination or injury on May 28, 1906, and one cubic centimeter withdrawn with a sterile pipette. This was diluted with sterile water to 1 to 100, 1 to 1,000 and 1 to 10,000, and plated in standard beef agar at a temperature below 45° C. Count of the colonies was made on the third and seventh days with the following results:

NUMBER OF BACTERIAL COLONIES.

CULTURE USED.	Third Day.				Seventh Day.			
	Number on Plate.			Number per c.c.	Number on Plate.			Number per c.c.
	1 to 100	1 to 1,000	1 to 10,000		1 to 100	1 to 1,000	1 to 10,000	
Alfalfa	Too many to count	490	0	490,000	Too many to count	800	0	800,000
Bean	174	4	0	17,400	176	4	2	176,000
Cowpea	0	0	1	0	0	0	1	0
Canada field pea	Too many to count	1,150[1]	65	1,150,000	Too many to count	1,100[1]	74	1,100,000
Sweet pea	0	0	0	0	0	0	0	0
Red clover	1	0	0	0	1	1	0	0
Vetch	0	0	0	0	0	0	2	0

[1] Estimated.

It seems clear from this table that the cultures of cowpea, sweet pea, red clover and vetch were sterile, while alfalfa, bean and Canada field pea contained germs in abundance. It is to be noted that there is no correspondence between the presumable age of the culture as indicated by its label and the prevalence of germs in it.

The colonies which did appear were quite uniformly one species and seemed to be those characteristic of the root tubercle organism, though through the pressure of the other work no further laboratory study was made of the organism.

Purity of the Cultures After Multiplication.

A portion of the contents of each tube which was tested, as recorded in the last paragraph, was placed in water, with the nutrient salts furnished us with the cultures, precisely as indicated and in the proportions indicated in the printed slip of directions accompanying the cultures, with the exception, however, that the utensils employed were much cleaner than would ordinarily be used in farm practice. At the end of two days, the time indicated in the directions for their use, these multiplying cultures were in violent fermentation, and microscopic examination revealed the presence of many species of bacteria and yeasts, as well in those which plating had shown to be sterile as in those which originally possessed bacteria. The evidence was that these multiplying cultures were seriously and grossly contaminated. Whether the root tubercle organism in such cases as they were alive could survive the severe competition occurring in such a contaminated, mixed culture is a serious and practical question.

Pot Experiments.

The practical question is whether these liquid cultures can be depended upon to produce tubercles upon appropriate legumes in soils devoid of root tubercle bacteria. To test this point, the following experiments were planned and carried out.

A soil consisting of equal parts of sand and red clay, well mixed and sifted through a sieve of one-sixteenth inch mesh, was weighed into six inch flower pots, 1,500 grams to each pot. Half of the pots was sterilized by heating for one hour in the autoclave at 120°, the remaining half was not sterilized. The pots were arranged in series of five each, and each series was supported in a separate wooden trough, out of contact with others. In the case of inoculated pots, all in a given series were treated with the same culture.

The series comprised the following combinations, each in sterile and non-sterile soils, and each series consisting of five separate pots:

Cowpea + cowpea organism.
Cowpea + 0 organism.
Cowpea + vetch organism.
Cowpea + bean organism.
Cowpea + alfalfa organism.
Canada field pea + Canada field pea organism.
Canada field pea + 0, organism.
Canada field pea + cowpea organism.
Canada field pea + vetch organism.
Canada field pea + alfalfa organism.
Canada field pea + sweet pea organism.
Vetch + vetch organism.
Vetch + 0 organism.
Vetch + cowpea organism.
Vetch + bean organism.
Vetch + alfalfa organism.
Alfalfa + alfalfa organism.
Alfalfa + 0 organism.
Alfalfa + cowpea organism.
Alfalfa + vetch organism.
Alfalfa + bean organism.
Sweet pea + sweet pea organism.
Sweet pea + 0 organism.
Sweet pea + Canada field pea organism.

All seeds were treated for two hours with 4 per cent formalin to kill any ordinary root tubercle organism present. Three modes of inoculation were employed: (1) Upon the surface of the soil in pot 1 was poured a portion of the culture just as received from Washington, indicated in the table as "direct." (2) To pots 2 and 3 were added portions of a multiplying culture made by following as precisely as possible the printed directions accompanying the culture, indicated in tables, as "according to directions." (3) To pots 4 and 5 were added portions of the multiplying culture mixed with a small quantity of soil, indicated in tables as "Mixed with soil." All inoculations were made at the time plants showed above soil.

Since the soil was very poor in nutriment, food materials, omitting nitrogen, were supplied by an application of a modified Knop solution.[1] During the growing period 300 cc. was added to each pot. The pots were watered daily with tap water unless the rainfall was ample. Toward the close of the growing season the plants were carefully removed from the pots, the earth washed away, great care being taken to loosen no tubercle, and the tubercles that had developed in each pot were counted and recorded. The results of these inoculations are exhibited with comments below:

TABLE 1.—SHOWING NUMBER OF TUBERCLES IN STERILE SOIL INOCULATED WITH GERM APPROPRIATE TO THE PLANT.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
22a, Sweet pea + sweet pea	0	0	0	0	0	0	0
17a, Alfalfa + alfalfa	0	7B[2]	1B	0	10	18	3 +
12a, Vetch + vetch	0	0	0	0	21	21	43 +
1a, Cowpea + cowpea	17T	54B	0	60B	7T	138	27
6a, Canada field pea + Canada field pea[3]	-----	----	----	----	----	56	------
						233	

TABLE 2.—SHOWING NUMBER OF TUBERCLES IN STERILE SOIL UNINOCULATED.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
23a, Sweet pea + 0	0	0	110B	60B	31B	102	20 +
18a, Alfalfa + 0	0	0	1	0	0	1	1
13a, Vetch + 0	0	6	0	0	0	6	1 +
2a, Cowpea + 0	3	12	2	38TB	30TB	85	17
7a, Canada field pea + 0							
All methods	-----	----	----	----	----	50	10
						244	

---

[1] Water 1000 cc., calcium phosphate, calcium sulfate, potassium sulfate, magnesium sulfate, one gram each, iron chloride, trace.

[2] B signifies that most of the tubercles were of the bottom of the pot, near or outside of the drainage opening. T indicates that most of them were at the top of the soil.

[3] In the case of the Canada field pea the number of tubercles from each pot was not kept, the total only being recorded.

On comparing Tables 1 and 2 it is seen that by using sterile soil the only significant gain from inoculation was in the case of cowpeas, the average rising from 17 uninoculated, to 27 inoculated. In both instances the majority of the tubercles were at either the bottom or the top of the pot, therefore presumably from aerial infection from the adjoining fields, which are known to be thoroughly inoculated with the variety of germ appropriate to this plant. The abundance of nodules on the uninoculated, sterile, sweet pea pots is due to the same cause, aereal infection, the nodules nearly all being at the bottom of the pot. There is no essential difference between the pots, due to the different modes of inoculation employed.

TABLE 3.—Showing Number of Tubercles in Non-Sterile Soil Inoculated with Germ Appropriate to the Plant.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
17b, Alfalfa + alfalfa	55	10	9	8	----	82	20
12b, Vetch + vetch	100	100	35	60	50	345	69
6b, Canada field pea + Canada field pea	-----	----	----	----	----	55	5
1b, Cowpea + cowpea	11	50	20	30	60	171	34 +
						653	

TABLE 4.—Showing Number of Tubercles in Non-Sterile Soil Uninoculated.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
18b, Alfalfa + 0	20	12	55	10	36	133	26 +
13b, Vetch + 0	70	68	60	40	35	273	54 +
7b, Canada field pea + 0	----	----	----	----	----	80	8
2b, Cowpea + 0	30	47	66	50	52	245	49
						741	

From Tables 3 and 4, experimenting upon non-sterilized soil, there is no significant increase in the number of tubercles from inoculation. The vetch roots bore slightly more when inoculated, and the cowpea roots more when not inoculated. Both variations were small and inoculations were doubtless without effect. There is no real difference in the results from different modes of inoculation.

TABLE 5.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
21a, Alfalfa + bean	1	0	4	1	0	6	1 +
20a, Alfalfa + vetch	0	2	0	0	0	2	.05
19a, Alfalfa + cowpea	0	1	2	1	1	5	1
						13	

TABLE 6.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
21b, Alfalfa + bean	33	14	21	45	23	136	27 +
20b, Alfalfa + vetch	35	45	41	40	25	186	37 +
19b, Alfalfa + cowpea	16	24	30	16	9	95	19 +
						417	

Tables 5 and 6 indicate clearly that the germ needed for alfalfa was present in the soil employed and that inoculation with the bean, vetch or cowpea organisms was ineffective in producing tubercles. Compare also the alfalfa entry of Tables 1 and 2, showing that the alfalfa germ was no more effective than any of the other germs for the alfalfa plant. The close agreement between the individual alfalfa pots lends strength to these conclusions and indicates that none of the various methods of inoculation employed are effective.

TABLE 7.—Showing Number of Tubercles in Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
16a, Vetch + alfalfa	22	87B	0	72T	----	181	45 +
15a, Vetch + bean	37B	49B	35B	3B	1	125	25
14a, Vetch + cowpea	0	25B	66B	8B	0	99	19 +
						405	

TABLE 8.—Showing Number of Tubercles in Non-Sterile Soil.

Plant Used and Organism Added.	Pot 1 Direct.	Pots 2 and 3 According to Directions.		Pots 4 and 5 Mixed with Soil.		Total.	Average.
16b, Vetch + alfalfa	90	57	85	35	37	304	60 +
15b, Vetch + bean	35	45	110	63	32	285	57
14b, Vetch + cowpea	36	55	40	26	45	202	40 +
						791	

Tables 7 and 8 show a decidedly larger number of tubercles on the non-sterile soil. The few that were present in the sterile pots were at the top or bottom and hence were derived presumably by aereal infection. These tables indicate that the bean, cowpea and alfalfa cultures were ineffective on vetch.

TABLE 9.—SHOWING NUMBER OF TUBERCLES IN STERILE SOIL.

Plant Used and Organism Added.	All Methods	Average.
11a, Canada Field Pea + sweet pea	0	0
10a, Canada Field Pea + alfalfa	0	0
9a, Canada Field Pea + vetch	10	2
8a, Canada Field Pea + cowpea	26	5 +

TABLE 10.—SHOWING NUMBER OF TUBERCLES IN NON-STERILE SOIL.

Plant Used and Orgaanism Added.	All Methods	Average.
11b, Canada field pea + sweet pea	134	26 +
10b, Canada field pea + alfalfa	20	4
9b, Canada field pea + vetch	48	9 +
8b, Canada field pea + cowpea	85	17

Tables 9 and 10 indicate a lack of efficiency of the various cultures to produce nodules on the Canada field pea, while the great number of tubercles in the non-sterilized pots shows the presence of the organism in the soil employed.

TABLE 11.—SHOWING NUMBER OE TUBERCLES IN STERILE SOIL.

Plant Used and Organism Added.	Direct.	According to Directions.		Mixed with Soil.		Total.	Average.
5a, Cowpea + alfalfa	4	80^{B}	7	----	3	94	23.5
4a, Cowpea + bean	16^{B}	86^{TB}	-----	27^{T}	10	134	34 +
3a, Cowpea + vetch	-----	21	90^{40B}	65^{30B}	38^{30B}	213	53 +
						447	

TABLE 12.—SHOWING NUMBER OF TUBERCLES IN NON-STERILE SOIL.

Plant Used and Organism Added.	Direct.	According to Directions.		Mixed with Soil.		Total.	Average.
5b, Cowpea + alfalfa	21	75	56	35	35	222	44 +
4b, Cowpea + bean	86	69	36	85	25	316	60 +
3b, Cowpea + vetch	60	55	55	46	74	290	58
						828	

Tables 11 and 12 indicate lack of effectiveness of the cultures. Table 11 shows aereal infection.

From a general summary of all the tables we find the following:

	Number of Tubercles per Pot
Sterile Soil appropriately inoculated	9.32
Sterile Soil not inoculated	9.76
Non-sterile soil inoculated	34.98
Non-sterile soil not inoculated	37.05
Pot No. 1 inoculated direct	24.18
Pots Nos. 2 and 3 inoculated according to directions	33 22
Pots Nos. 4 and 5 inoculated by soil	24.39

It seems throughout these tests that there is no essential difference in results from the different methods of inoculation employed. The general presence of tubercles upon all plants in non-sterile soil shows the presence of proper germs in the soils employed. There is a general lack of infection in sterile soil with alfalfa and Canada field pea, indicating a relative rarity of those germs in the air. These crops are not grown in the immediate vicinity.

There are many tubercles even in sterile soil on vetch and cowpea, due to aereal infection of the soil. This indicates an abundance of these organisms in the air. These plants grow in abundance in adjoining fields.

The abundant aereal infection of these two crops, which are commonly grown here, and the slight aereal infection of crops not grown here, points strongly to the varietal independence of the organisms, to the special adaptability of the organisms to special crop plants.

SUMMARY.

The facts as detailed are—

That many of the cultures when received were devoid of live organisms of any kind, as is shown on page 50.

That in multiplying the cultures, even under cleanly laboratory conditions, there is gross contamination by molds, yeasts and foreign bacteria. (See page 51.)

That in the pot experiments there was rarely any increase in the number of tubercles due to inoculation. The cultures here used were obtained directly from the National Department of Agriculture, and were fresh. They were probably of as good quality as is to be obtained and were presumably superior to the commercial cultures upon the market.

While the number of tests here recorded is not large, it is to be noted that these tests were made under circumstances highly favorable to the cultures, and it is a reasonable supposition that failure would be more liable to occur in actual farm practice than in these pot tests.

It therefore appears that the method of inoculation with liquid cultures, as at present prepared, is uncertain and unreliable, and not to be recommended as a substitute for the method of inoculation with soil containing the appropriate organisms.

NOTE.—Since writing the above, Farmers Bulletin 315, "Progress in Legume Inoculation" of the U. S. Department of Agriculture has come to hand, and our conclusion that inoculation by liquid culture is not reliable, seems to us to be supported by the fact appearing in that bulletin since out of 4296 inoculations made by farmers in many sections of the United States 2087 were of doubtful results and only 1770 were successes, or less than 50 per cent. We wish again to emphasize the dangers of inoculation by soils as set forth above (page 48) and on page 14 of Farmers Bulletin 315 and to call attention to the necessary precaution of knowing the origin of the soil to be employed for inoculation purposes.

NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

BY F. L. STEVENS AND J. G. HALL.

ALFALFA; DODDER (*Cuscuta*) was reported as bad in Mecklenburg County. This disease has been reported from Jackson and Orange counties as well.

APPLE, THE FLY SPECK, AND THE SOOTY MOLD are very prevalent on nearly all apples exhibited for sale on the Raleigh markets, making them extremely unsightly and diminishing their market value.

APPLE ROOT ROT (*Clytocybe*).—This toad stool, growing upon the roots of apple trees, caused their death in Haywood County, being especially bad in young orchards.

APPLE BLIGHT (*Bacillus*) is prevalent throughout the State. It has now been recorded from more than half the counties of the State. It was noted in especially severe form this year in Transylvania County.

A very destructive outbreak in a rather unusual form also occurred at Waynesville, Haywood County. In an orchard of eighty trees nearly forty were seriously attacked. In some instances the tip of the twig died from the end backward with a blackening of the cambium. The most common symptom, however, was a blackening of the bark in the crotches of the branches, which was of such nature as to call forth the comon name, "the dry rot," from the owner. The blackening characteristic of the bark prevailed to a distance of several inches from the point of infection. So abundant were the diseased spots on the trees that the trees were deemed worthless. Microscopic examination revealed cells full of the characteristic bacilli.

APPLE FIRE BLIGHT, FOLLOWED BY *Sphæropsis* AND *Coniothyrium*.—Several specimens have come to hand this year, notably from Rutherford and Vance counties, which have all the appearance of being typical fire blight. The bark was shriveled and hard in the affected portions; the boundary between the diseased parts and healthy parts was sharp, and longitudinal cracks were apparent there, due to the unequal tension caused by the continued growth in the healthy bark. The cambium and often the wood was blackened in the manner characteristic of this disease.

Unlike the ordinary fire blight these twigs were thickly set with pycnidia. These pycnidia proved, upon examination, to be in many instances Sphæropsis, and in many other instances Coniothyrium, while occasionally other fungi were present. The most frequent pycnidial forms, however, were Sphæropsis and Coniothyrium. Upon close examination it seemed apparent that the death of the twig was caused by the usual fire blight, and these other fungi followed almost immediately as saprophytes upon the dead twig.

The presence of these two fungi in such abundance upon the twigs is significant, since it shows that twigs dead of the blight may serve as a multiplying and breeding ground for these two fungi, which are so destructive to fruit in other seasons of the year.

The fire blight is bad enough on its own account, but in the light of the facts just related it becomes doubly important to cut out and burn all of the fire blight as soon as it appears, in order to minimize the possibility of the dead twig produced by the fire blight serving to spread these other rot-causing fungi.

APPLE CROWN GALL has been heard of during this year from Lenoir and Rowan counties, in spite of the efforts made to prevent its distribution. It is now known in fifteen counties of the State.

APPLE BLACK ROT (*Sphæropsis*).—A peculiar condition of this disease was noted in specimens received from Vance county, consisting of a complication of the blight with the black rot fungus. (See Apple Blight).

APPLE BLACK ROT (*Sphæropsis*) was found abundantly upon twigs sent to the Station from Rutherford and Vance counties.

APPLE (*Coniothyrium*).—This fungus was in several instances found causing a rot of the apple.

APPLE (*Vollutella*).—A rot due to this fungus was collected at several points in the State.

APPLE LEAF SPOT (*Phyllosicta sp?*).—This disease is the worst with which the apple growers of the western section of the State have to contend. While the disease is very widespread and probably occurs in every county of the State, its damage is comparatively insignificant east of the mountain section, although specimens of it have heretofore been received from Halifax, Rockingham, Wake, Alamance and Guilford counties. It was noted this summer in a specially destructive form in McDowell, Madison, Buncombe, Henderson, Haywood, Transylvania, Jackson, Macon, Graham, Clay and Cherokee counties. This is the one disease, more than any other, that necessitates spraying of apples in the mountain section. It is fortunately comparatively easy to control by this means.

APPLE, BITTER ROT (*Glœosporium*).—Complaints of bitter rot of apple were received from Polk county. It was estimated that there was thirty per cent loss there from this disease.

APPLE RUST (*Gymnosporangium*).—This disease was most prevalent, as usual, in the Piedmont section. In the mountain section there is much less of it. In only one commercial orchard was much damage noted, and this was attributable to neighboring cedar trees. Some rust was noted in Jackson, Transylvania and Burke counties. The general appearance of this rust, as it occurs on the lower side of apple leaves, is shown in Fig. 18.

APPLE SCAB (*Fusicladium*) prevails throughout the State on unsprayed orchards.

ASPARAGUS RUST (*Puccinia*) was very abundant in Wake and in Warren counties.

ASTER RUST (*Coleosporium*).—A rust due to Coleosporium affected cultivated asters grown in West Raleigh to a very serious extent. The under sides of the leaves become very thickly dotted with spots of spores. Shortly after the appearance of the spores the leaves shrivelled, and in many instances the plant died as a result of the attack.

BEAN ANTHRACNOSE (*Colletotrichum*).—This disease prevails throughout the whole coastal section from Norfolk to Wilmington, the damage often ranging from fifty to seventy-five per cent of the crop. It develops with great rapidity on the pods after they are picked, and beans which are placed in the car in apparently healthy condition may arrive on the Northern markets badly spotted, thus greatly depreciated in market value.

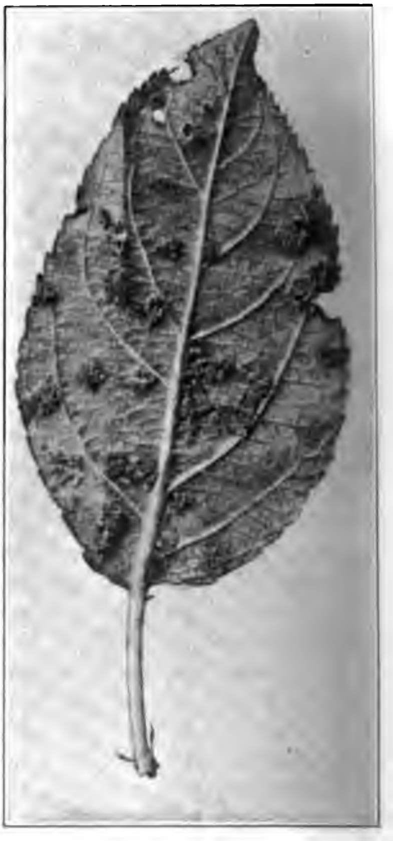


FIG. 18. - An apple leaf affected with apple rust.

BEAN BLIGHT (*Phytophthora*) was noted in Wake county, the damage being, however, slight.

BEETS; LEAF SPOT (*Phyllosticta*) was noted on beets grown in cold frames at Wilmington. Damage was slight.

BOSTON IVY.—This plant, as usual, was abundantly affected with *Phyllosticta,* the same which forms the conidia stage of the black rot of the grape.

CABBAGE AND COLLARD YELLOW SIDE, reported from Halifax county as causing 75 per cent loss. This is very widespread in this State.

CABBAGE CLUB ROOT (*Plasmodiophora*), reported from Kinston, Lenoir county, and also from Bertie and Robeson counties. It has also been reported from Franklin, Guilford and Rockingham counties.

CABBAGE BLACK ROT (*Pseudomonas*).—Many cabbage fields in Transylvania county are deprived of their usefulness for raising cabbage through the introduction some years ago of this disease, probably through seed. The disease is spreading constantly, invading new ground, and is a serious menace to the cabbage raising industry of that section. The strictest care to prevent its spread must be exercised. This disease is rather widely distributed, particularly in the east, although it has not invaded, to any large extent, the regions in which cabbage are grown commercially.

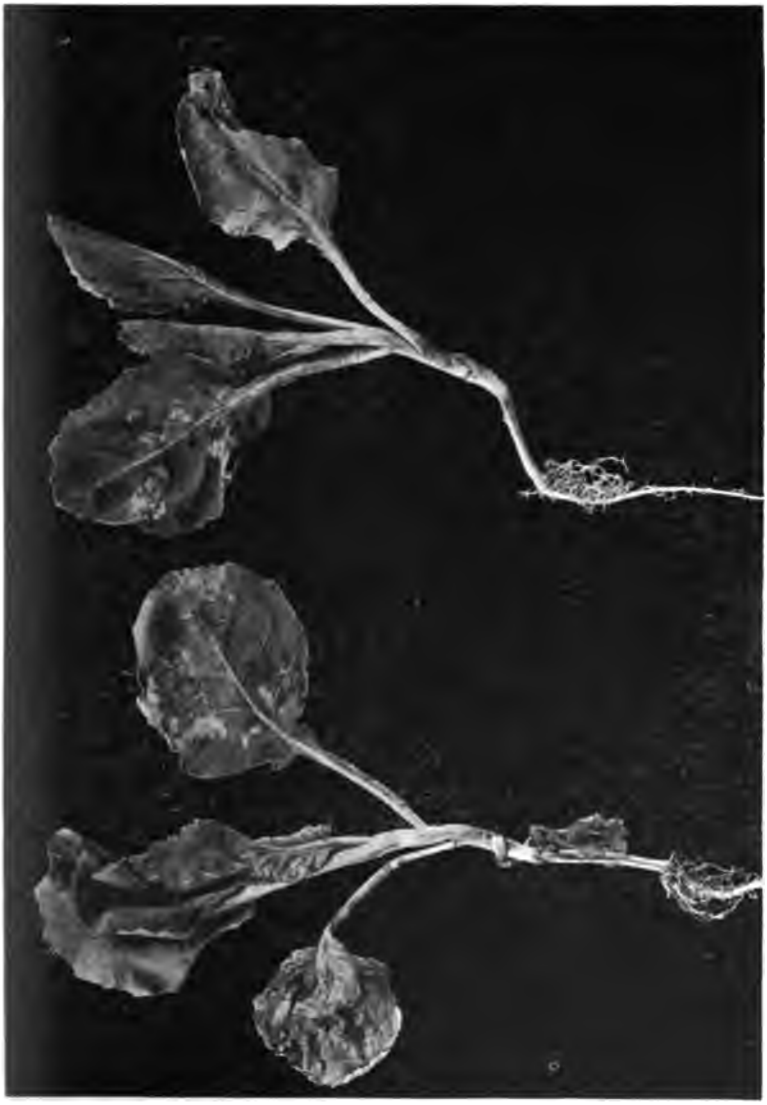


FIG. 19.—Cabbage plants affected with the downy mildew.

CABBAGE, DOWNY MILDEW (*Peronospora*).—This is the same disease as mentioned on page 63 as affecting the collard. Specimens of diseased young plants, as shown in Fig. 19, were received from Fayetteville with the complaint that this disease was doing serious damage to the crop in some fields in Cumberland county. This is the first time that this disease has been noted in this State. It was first noted in the United States by Professor Halsted, who in the New Jersey Report for 1890 says the disease "was found upon the outer leaves quite generally in one large field, causing the leaves to wilt and die." The fungus was also noted in Massachusetts in the report for the same year as occurring to a considerable extent on a plot of purple topped white turnips. Halsted, in the New Jersey Report for 1894, again made mention of this fungus as abundant upon the lower leaves of young cabbage plants. It was also reported upon cabbage in Maryland in 1902 by J. B. Norton, and in the same State in 1904.[1] He says "it is bad on young plants, also on half grown cabbage." As to treatment, he says, "The Bordeaux mixture applied frequently to young plants was also very effective, together with forcing by nitrate of soda and withholding water."

CABBAGE (*Sclerotinia*).—Sick cabbage plants were received from J. B. Ingram, of Lilesville, Anson county. The plants showed in the tissue an abundance of mycelium, and upon being placed in the culture dish there soon developed a very luxuriant growth of white mycelium, and later sclerotia characteristic of Sclerotinia.

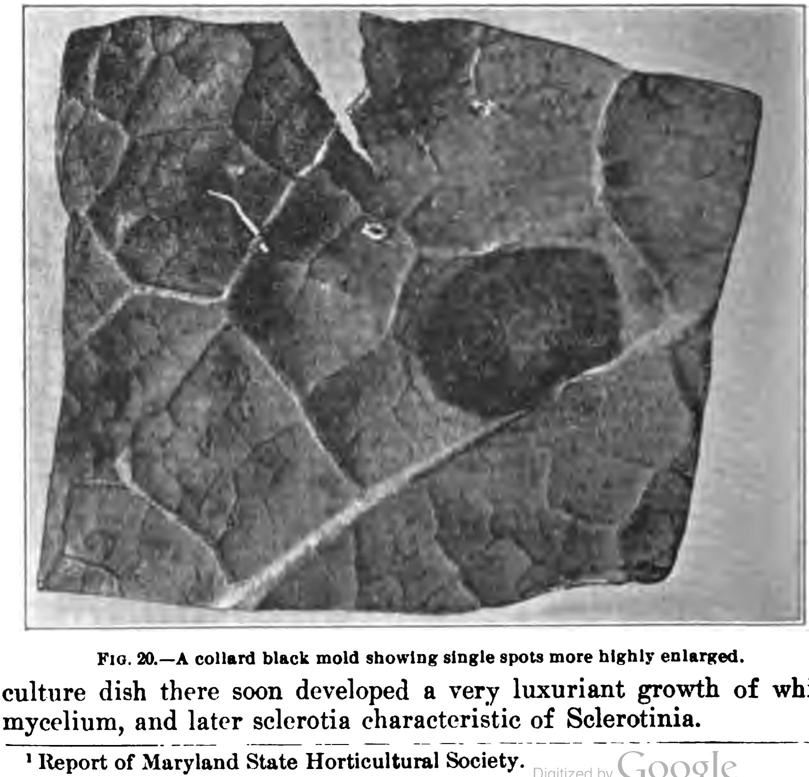


FIG. 20.—A collard black mold showing single spots more highly enlarged.

---

[1] Report of Maryland State Horticultural Society.

Cabbage Black Mold (*Alternaria*) was sent to the Station from Lilesville by Mr. Ingram.

Cantaloupe Blight (*Alternaria*), as shown in Fig. 21, is very widespread throughout the State. Especially bad reports have been received of it from Warren, Rowan, Scotland, Cumberland and Pender counties. In Warren one grower attributed the loss of half of his crop to this disease.

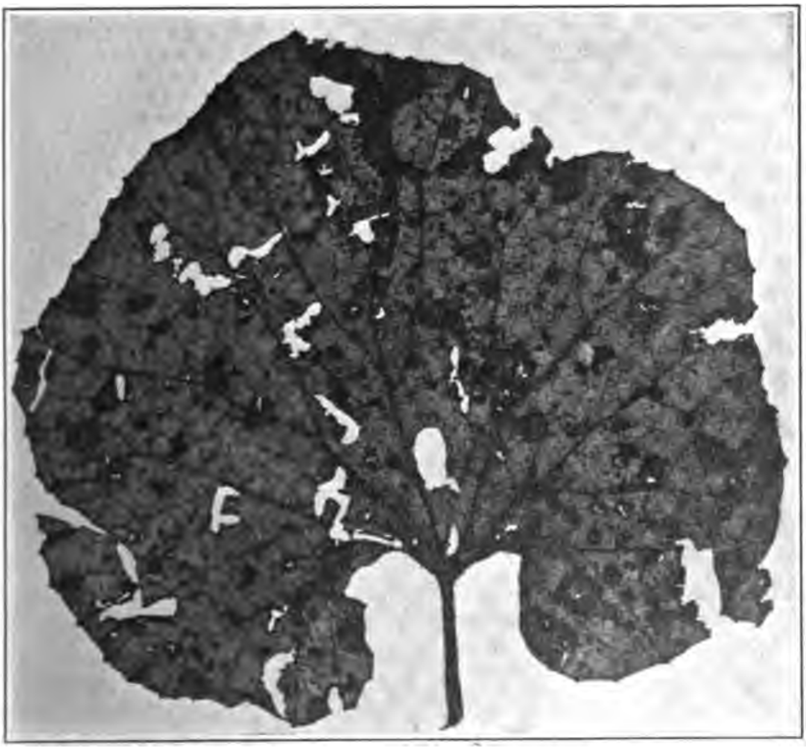


Fig. 21.—Cantaloupe leaf blight.

Cantaloupe (*Nematodes*).—Root galls due to nematodes were very numerous in some fields in Rowan county.

Carnation, Bacterial Spot (*Stigmonose*) is very widespread and destructive.

Carnation Leaf Spot (*Septoria*) is noted to only a very slight extent.

Cherry, Black Knot (*Plowrightia*).—See Fig. 22. This disease was noted in specially destructive form this year in Macon, Jackson, Haywood and Wilkes counties. One correspondent writes, "The Morel cherry, once so plentiful and nice for cherry bounce, has been virtually exterminated by the black knot in many sections of the mountain region, and raising of cherries has been abandoned on account of this disease." See Fig. 23, page 68.

CHERRY, SHOT HOLE (*Cylindrosporium Padi*) abounds on cherry leaves to an injurious extent, principally upon neglected trees.

CHESTNUT (*Monochætia*).—The trees throughout the mountain region are largely affected with a brownish spotting of the leaves, the spots being circular, ranging in size from that of a dime to a quarter of a dollar, and usually showing concentric markings. The diseased spot was thickly beset with acervuli, bearing characteristic spores of Monochætia. The fungus seems unquestionably to be *Monochætia-pachyspora* of Bubak.

CHRYSANTHEMUM, LEAF SPOT, due to *Cylindrosporium*, was very prevalent in the green-houses of Raleigh. This disease is very much more destructive upon early varieties than late varieties, as Polly Rose and Colonel Appleton.

CHRYSANTHEMUM, RAY BLIGHT.—This new disease was reported to the Station from Cumberland county, and was also found in Wake County. It was doubtless widespread upon chrysanthemums. This disease is made the subject of a separate section in this report.

CLOVER ROOT ROT, of unknown cause, is complained of in Randolph county.

COLLARD, BLACK ROT (*Pseudomonas*).—See cabbage.

COLLARD, SOFT ROT, of unknown cause, is reported as very bad in Wake and Johnston counties.

COLLARDS, DOWNY MILDEW (*Peronospora*).—In late October, 1906, collards growing in some of the gardens in West Raleigh were found to be seriously affected with the downy mildew.

This mildew manifests itself as angular spots limited by the veins, having a pale yellow appearance from above, while upon the under side there develops a growth of the spore-bearing branches of the mildew.

The diseased spots are lighter colored, pale yellow, and shrunken. On the under side of the leaf on these spotted regions is seen a fine, white down. It is from this down that the name "downy mildew" is derived.

COLLARD, BLACK MOLD (*Alternaria*).—This disease differs strikingly from the mildew, in that the affected spots are nearly black; are marked by concentric circles, are more circular and less angular than the mildew spots, and less definitely bordered, *i. e.*, they shade off more gradually into the surrounding healthy tissue.

The general appearance of this disease, as seen from the upper surface, is shown in Fig. 20. It will be noticed that in the upper surface the spot appears shrivelled. It is pale green in color. Seen from below the spot is densely black, strongly contrasting with the downy mildew mentioned above.

The black mold and downy mildew were found associated together upon the same plants in some gardens, and the damage was very great, in many instances resulting in the death of the plants.

Corn Rust (*Puccinia*).—This rust is widespread throughout the State, but of very slight damage.

Corn Mold.—Owing to the damp season this disease has been more damaging this year than any previous year on record.

Corn Smut (*Ustilago*) is everywhere, varying in damage probably between 1 and 5 per cent of the crop in different portions of the State. The spores of this fungus can gain entrance into the plant apparently at almost any time during the season. Seed treatment is of no avail. If all of the smut balls be cut out and burned or buried with lime each year the loss from this disease will gradually be reduced to a minimum. The question of the economy of this mode of treatment will be left to the judgment of the individual farmer. Some farmers do practice it and believe it pays. Others prefer to suffer the loss, not regarding the gain from treatment commensurate with the cost of treatment. The use of the silo will certainly accomplish the same result much more economically, since the heat normally generated in the silo is more than ample to kill the smut spores. Different portions of a corn area of a farm can in successive years be harvested into the silo, smut and all, and the smut thereby killed, thus eventually rendering the whole farm comparatively free from this disease.

Cotton, Frosty Mildew (*Ramularia Areola*) is found in nearly all cotton fields. The injury caused is not felt by the grower, though in reality the damage done per acre is probably considerable. Little is known of this disease except that it is caused by a fungus.

Cotton Wilt (*Fusarium*).—Complaints from this disease, in addition to those counties previously heard from, came from Kinston, Lenoir county, this year.

Cotton, An Unknown Disease, apparently caused by bacterium, was received from Reepsville, Lincoln county, this year.

Cotton Anthracnose (*Colletotrichum*) was received from Anson County. It has previously been troublesome in Robeson, Wake and Edgecombe counties.

Cowpeas, *Cersospora* and *Amerosporium,* prevail upon cowpeas nearly everywhere in the State, but the damage is not great.

Cowpea Wilt (*Fusarium*) was seen in an extremely destructive form in Camden and Pasquotank counties. It has since been complained of in Mecklenburg and Johnston counties.

Cucumber Blight (*Alternaria*) was destructive this year in Lenoir, Pender and Robeson counties.

Cucumber Anthracnose was complained of from Robeson county.

Figs (*Cercospora*).—This fungus is abundant upon the fig, especially late in the season, when it causes the leaves to yellow and fall prematurely.

Grape, the Black Rot, was seen in destructive form upon the scuppernong in Wake county. This disease prevails as usual throughout the Piedmont and mountain portions of the State upon all vines not protected by spraying. Sprayed crops were, however, raised in perfect condition.

Lettuce Mold (*Botrytis*) was seen in Cumberland, Duplin, Cleveland and New Hanover counties, usually to a very slight extent, though it was destructive in Duplin county. In some instances the seed bed was very badly affected with this fungus. This was notably so at Wallace this spring, plants in many places in the bed being completely killed out. This form of fungus also causes a loss to the lettuce as it approaches maturity, particularly if ventilation is not properly handled. The damage by botrytis was very slight, practically not noticeable at New Bern. There was, however, considerable of it at Fayetteville, Wilmington and Mount Olive.

Lettuce, Nematodes.—Abound upon the roots in the seed bed and cold frames.

Lettuce, Drop (*Sclerotinia*), (large sclerotium form), was collected in Cumberland, Robeson, Craven and New Hanover counties, where it was exceedingly destructive, the loss ranging from 20 to 50 per cent. It prevailed this year throughout the lettuce section as formerly, being in most instances worse than in previous years. It is very rarely reported serious upon the fall crop, however, in one instance this year it seriously affected this crop, and also the seed beds.

Lettuce Leaf Spot (*Septoria consimilis*).—Prevails on old lettuce plants which have gone to seed, killing the older leaves and often many of the younger ones, and spotting all of the leaves of the plant. Upon the market lettuce in the beds it is usually held in moderate check, but even in the best of beds of the State many of the plants were found with the lower leaves affected and dying and the younger leaves bearing a few, though harmless spots. The death of the lower leaves from the attack of this fungus is regarded by the grower as a natural condition. It necessitates trimming before marketing, with a resulting diminution of the size of the head and a loss of market value. In some parts of the State, notably Cumberland county, this disease caused much damage in some beds, occasioning small, worthless plants.

The amount of this disease can surely be diminished in all regions by taking care that no plants are neglected and allowed to go to seed in the bed or seed bed to thus serve as a breeding place for the pest.

The disease is caused by a fungus, the spores of which fall upon the leaf, grow, penetrate the leaf and cause the bleached spot. The fungus then fruits with a small, spherical, hollow body, the pycnidium. In [illegible] re borne countless spores to further spread the infection.

Medlar, **Rust** (*Roestelia*) was found upon specimens of this Japanese plant grown in the park at Raleigh. The rust, in most instances, affected the fruit itself, though sometimes found upon the leaves.

Medlar.—This tree is also, as might be expected from its close kin to the apple, subject to the familiar apple blight, fire blight, *Bacillus amylovorus,* and the trees intended for ornaments were rendered unsightly objects.

Mulberry, **Nematodes.**—Specimens of seedlings were received from Johnston county. Upon the roots was a great abundance of small galls, which, upon examination, proved to be due to nematodes.

Oats, **Smut** (*Ustilago*).—As usual prevails throughout the State except where the formalin treatment is employed. Specimens were received from Bertie and Moore counties. The estimated loss to the State this year is placed at 12 per cent of the total crop. Formalin is coming into more general use and the loss is thereby diminished.

Pea (*Ascochyta*).—Leaves of the cultivated garden pea affected with ascochyta spots, also pods affected with this spot were collected both at Goldsboro and New Bern this year. The damage under the prevailing weather conditions there this year was not serious.

Peach *Cercospora* was collected in Rowan, Wake and Craven counties. It seems to be widespread upon the peach, but occurs chiefly in the fall, and does damage only upon young nursery stock.

Peach, **Brown Rot** (*Sclerotinia.*)—Complaints from this disease were received from McDowell county. In the peach growing section this disease is giving way to spraying.

Peach Rust (*Puccinia pruni*) was collected at West Raleigh, Wake county, also at Craven county in the autumn. No record of real damage from this parasite has been reported from the State. Indeed we have no other record of its collection in North Carolina with the exception of one specimen collected in Wake county about two years ago.

Peach, **Frosty Mildew** (*Cercosporella Persica, Sacc*), was very abundant throughout the year. Specimens were submitted from several portions of the State. The disease is widely spread and often serious. There is no record of its injuring orchards that are well cared for and properly sprayed. It occurs chiefly on neglected trees or young stock. Specimens of this disease were received from Rowan and Wake counties. Proper spraying will hold it in check.

Peach Yellows.—Specimens of this serious disease were received from Buncombe county. With the exception of Tryon and Saluda, these are the only specimens known to be taken in this State. This is one of the worse peach diseases and every precaution should be taken against its spread.

PEANUT *Cercospora* was collected from Wake and Duplin count

PEAR BLIGHT (*Bacillus*) (Fig. 22).—The pear blight has b exceedingly bad this year, worse than ever before observed in

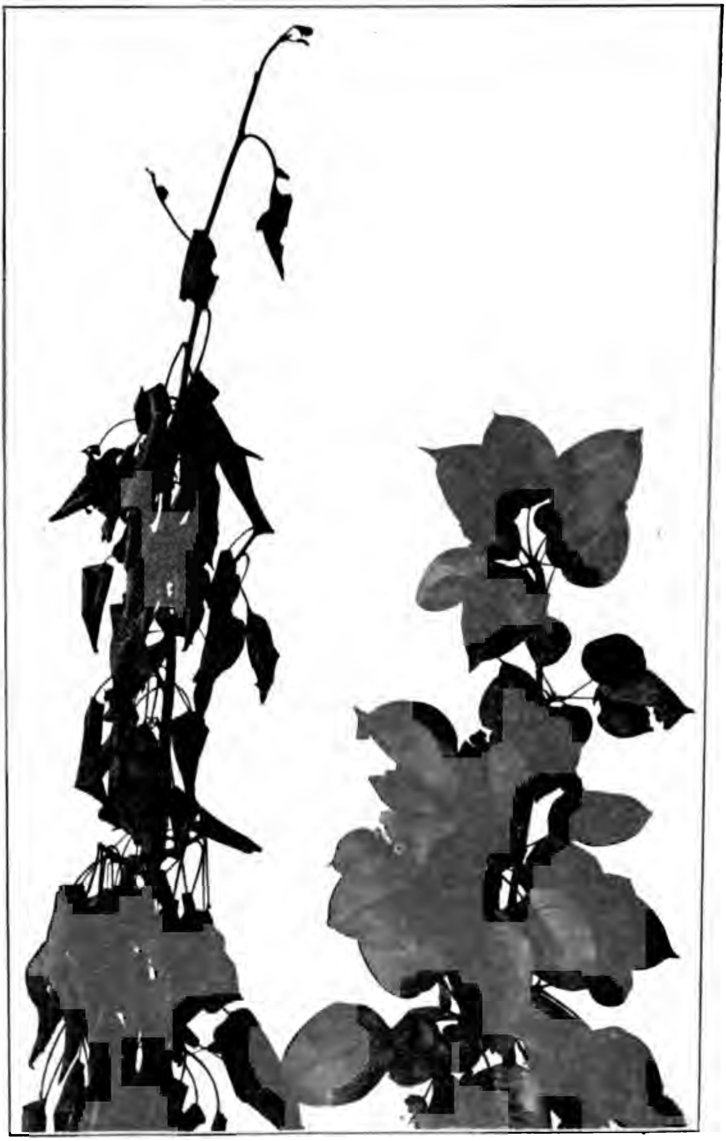


FIG. 22 —Pear blight: a, healthy twig; b, characteristically diseased twig.

State, and letters have been received from all parts of the State inquiring concerning the cause and anture of this disease. In several instances complaint has been made that even the Keiffer and Leconte have been blighted so badly as to kill whole orchards.

Especially does it seem to have been troublesome this year in Moore and Rowan counties.

Plum Pockets (*Exoascus*).—One case was noticed in Wake county.

Plum, Brown Rot (*Sclerotinia*) was worse this year than previous years. The loss estimated for the State is 50 per cent.

Plum, Black Knot (*Plowrightia*) (see Fig. 23).—Specimens of this disease were received from Alamance county, where it was said to be of damaging importance.

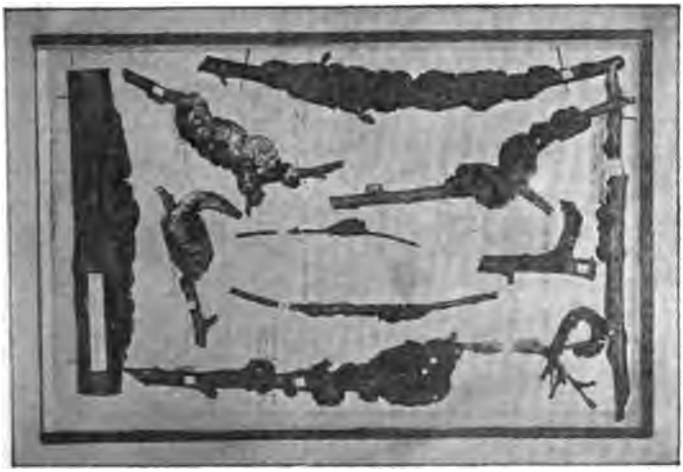


Fig. 23.—Plum Black Knot.

It is also very prevalent in the western mountain section. In Haywood county common saying reports it as the cause of the destruction of the plum and cherry industry in the lowland. Some of the worst specimens of this disease ever seen by the writer were collected in Macon county. It is to be fought by cutting and burning.

Potato, Early Blight (*Alternaria*) was seriously destructive in Randolph, Wake, Cumberland, Wayne, Lenoir, Duplin, Bladen and Columbus counties.

Potato Scab was said to be serious in the trucking region. Complaints in particular were received from Mount Olive.

Quince, Blight (*Bacillus*).—This disease was seen in Transylvania county. It had previously been reported from Buncombe county.

Quince, Rust (*Gymnosporangium*).—This rust upon the fruit of the quince has been recorded from Rockingham, Rowan, Gaston, Buncombe, Transylvania and Cherokee counties. It was seen in Transylvania County, and had been previously reported from many of the western counties of the State.

ROSE, POWDERY MILDEW (*Sphærotheca*).—Complaints of this common mildew were received from Lincoln, Pitt, Duplin, Sampson and Edgecombe counties. It is easily controlled by spraying.

ROSE, BLACK SPOT (*Actinonema*) is abundant throughout the State on roses outdoors and under glass.

SALSIFY, NEMATODES (see Fig. 24).—Specimens of very badly affected roots of this crop were received from Durham county, with a statement that portions of the soil were affected and other portions of the same row were free.

STRAWBERRY LEAF SPOT (*Sphærella*).—This disease was seen in Duplin, Pender, Columbus, Vance and Wake counties. It probably exists wherever strawberries are grown and is sometimes of very serious import. Valuable varieties have been protected by spraying. Some varieties are much more susceptible to the disease than others, and owing to the susceptibility of some of our best varieties, we are unfortunately prevented from growing them.

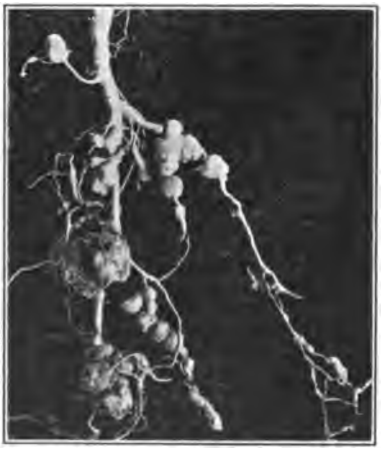


FIG. 24.—Salsify, vegetable oyster, root showing nematode galls.

SWEET POTATO LEAF SPOT (*Phyllosticta*) was very abundant in Wake county, and doubtless diminished the vigor of the vines somewhat, though to no very great extent.

SWEET POTATO WILT (*Fusarium*).—Reports from sections affected with this disease show less destructiveness than in previous years.

SWEET POTATO SOFT ROT (*Rhizopus*).—This fungus is the cause of most of the rotting of potatoes while in storage, and occurs extensively throughout the State.

TOBACCO, THE GRANVILLE TOBACCO WILT.—Continues to spread and is reported as worse this year, and the loss is said to be 25 to 100 per cent of the crop in the affected region. The loss in one county is estimated this year at $20,000. It was estimated to be 40 per cent more destructive this year than last year.

TOMATO WILT (*Bacillus*).—In addition to counties previously reported it was noted this year in Vance, Wake and Bladen counties.

VETCH (*Ascochyta*).—Specimens of vetch from New Bern and also from Raleigh exhibited disease in the form of small spots upon leaves and stems. The spots were ashen or brown in the center, with a rather wide border of dark red. Each spot bore several pycnidia containing spores of the ascochyta type. It is evidently *Ascochyta Viciæ* Lib., which has been noted by Dr. G. P. Clinton, of the Connecticut Agricultural Experiment Station, as injurious in that State upon cultivated vetch.

VIOLETS.—The *Cercospora* of the violet ranks as one of the worst greenhouse diseases of the State.

WATERMELON WILT (*Fusarium*).—In addition to counties previously reported, it was heard from this year in Halifax, Robeson, Lenoir, Duplin and Pender counties.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 14.—DECEMBER, 1906.

A SERIOUS LETTUCE DISEASE.

Throughout the lettuce growing section, and particularly conspicuous in the neighborhoods of New Bern, Wilmington, Fayetteville and Maxton, occurs a disease of lettuce of extreme severity and destructiveness. It may be easily recognized by its symptoms.

The disease begins with the wilting of the outer lower leaves, which droop and fall flat upon the ground. A similar fate rapidly overtakes the inner leaves, and so on over the whole plant, till within a few days the entire plant is dead, lying flat upon the ground.

Upon the under side and at the base of the leaves will be noticed, at this time, dense cotton-like growths (Mycelium), and in the later stages small black, irregular bodies (Sclerotia), from a quarter of an inch to a half inch long and somewhat less in thickness will be found in similar situations. The sclerotia and mycelium are unmistakable signs of this disease.

This disease is known as the "drop," and has for several years been a serious menace to lettuce growing in many portions of the United States. It is caused by a fungus visible to the eye as the mycelium and sclerotia referred to above. If this fungus once gains entrance to the lettuce bed, no certain, or at least no economical treatment is known to get rid of it.

It is therefore extremely important that all growers who are now free of this disease take every precaution to keep free of it, also any growers who have a portion of their beds free should use every precaution to keep that portion from becoming infected.

These precautions consist in preventing any diseased plants or fragments of diseased plants or any of the mycelium or sclerotia from obtaining access to uninfected fields or beds. As soon as any plant shows an indication of this disease the plant should be pulled up, buried with lime, or destroyed by fire. The spot from which the plant was pulled should be thoroughly drenched with Bordeaux Mixture. If these precautions are followed, by those people who are not at all or only slightly affected with this disease, it will probably be possible to hold the disease in check.

F. L. STEVENS,
Biologist.

PRESS BULLETIN No. 15.—OCTOBER, 1902.

Revised January, 1907.

TREATMENT OF OATS, WHEAT, RYE OR BARLEY FOR SMUT.

Very few farmers realize the full extent of the injury suffered by these cereal crops through the inroads of smut. The smutted plants are dwarfed, therefore escape observation so completely that even very observing farmers often allow as much as 25 to 35 per cent of smut to pass unnoticed. Smut is rarely less than 10 per cent in oats, and is frequently 16 to 25 per cent. This is a complete loss to the farmer, as it costs as much in seed, land and tillage to raise the smutted plant as to raise the full head. All of this loss can be turned into a clear profit at a cost of about one cent per acre for material and a very slight outlay of labor. The United States is suffering annually a preventable loss of about $18,000,000 from the smut of oats alone. Our own State is yearly losing between 10 to 20 per cent of her annual oat crop, ranging in value at about $991,516.00.

RATIONALE OF TREATMENT.

The smut of grain is caused by a fungus, the spore (the spore is the reproductive body of fungi, corresponding to the seed in higher plants), of which is carried in the seed to the young grain plant. Smutted plants in the field, and in threshing, shed their spores in the air. These spores are then carried about by the wind, many of them finding lodgment in the seed of neighboring plants. They are thus planted with the grain and the same moisture, warmth, etc., which starts the plant into renewed life quickens the smut. It thus happens that many young plants are, in earliest infancy, attacked by the smut enemy, which, having gained entrance, lurks within the plant until blooming time, when it again breaks forth in its well-recognized form. Only very young plants are susceptible to attack of the smut, therefore if we can so treat the seed of the plants as to destroy the adhering spores of the fungus without injuring the grain, we can enable the young plant to pass the critical stage of its existence in safety. It is thereafter safe. Such treatment is possible. Smut can therefore be practically eliminated from the field. Several kinds of treatment are effective, but of all those known that by formalin is by far the best and cheapest, although the familiar bluestone treatment is quite efficient in wheat.

TREATMENT.

Formalin can be purchased from a druggist at a cost of from 75 to 95 cents per pound. One pound mixed thoroughly with 45 to 50 gallons of water is sufficient to treat 45 to 50 bushels of grain.

To treat the grain, spread it in a thin layer on a smooth barn floor and sprinkle with the diluted formalin, using either a spraying machine or a watering-pot. Sprinkle so as to thoroughly and evenly wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution and cover the pile with canvas, carpets, blankets, or bagging, to keep the fumes of the formalin within. The pile should stand from 6 to 12 hours in this way. The oats may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning-mill, or the lime may be omitted if desired. It is merely a drying agent. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection. The best way is to treat, dry, then sow as soon as is practicable.

In general, one gallon of mixture will suffice to treat one bushel of grain. The formalin should be used at the rate of one ounce to three gallons of water.

Formalin is an irritating caustic, which should not be brought into contact with the skin in pure form. In diluted condition it is harmless.

If you try this treatment simply as an experiment, sow the treated seed in a definitely marked portion of your field, using all care to keep the treated seed from smutted seed. If you are adopting this treatment for your whole sowing, it will be instructive if you will leave a small porotion, say one or two drill rows, with the same seed, untreated, thus enabling you to determine the real value of treatment.

We should be pleased to have you send a letter to the Station stating the results of your treatment, its cost, labor involved, amount of smut in treated and untreated fields. The amount of smut should be very carefully estimated in per cent from an actual count in the field.

F. L. STEVENS,
Biologist.

Bulletin No. 195 **June 1907**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

WEST RALEIGH

FARM POULTRY

PART OF POULTRY BUILDINGS AT EXPERIMENT STATION

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATIOI

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

S. L. PATTERSON, *ex officio* Chairman, Raleigh

J. J. LAUGHINGHOUSE	Greenville	A. T. MCCALLUM	Red Sprin
C. W. MITCHELL	Aulander	J. P. MCRAE	Laurinbu
WM. DUNN	New Bern	R. L. DOUGHTON	Laurel Sprin
C. N. ALLEN	Auburn	W. A. GRAHAM	Machpela
R W. SCOTT	Melville	A. CANNON	Horse Sh

STATION STAFF

GEO. T. WINSTON, LL. D., President of the College

B. W. KILGORE	Director
W. A. WITHERS	Chemist
TAIT BUTLER	Veterinarian
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
FRANKLIN SHERMAN, JR.	Entomologist
C. B. WILLIAMS	Agronomist
W. N. HUTT	Horticulturist
C. M. CONNER	Agriculturist
F. C. REIMER	Assistant Horticulturist
J. C. KENDALL	Assistant Dairy Husbandry
WILLIAM KERR	Assistant in Field Experiments
W. A. SYME	Assistant Chemist
J. G. HALL	Assistant Vegetable Pathologist
W. C. ETHERIDGE	Assistant in Farm Crops
J. C. TEMPLE	Assistant Chemist and Bacteriologist
A. F. BOWEN	Bursar

The Bulletins and Reports of this Station will be mailed free to any residen of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station

Address all communications to

AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

Page.

Introduction 5
Houses and Yards 5
Breeds of Fowls 11
Selecting the Breeding Stock 20
Feeds and Feeding 21
Effect of Green Food on Fowls 22
Animal Food 23
Egg Production 25
Comparative Keeping Quality of Fertile and Infertile Eggs 27
Incubation 28
Health and Disease 34

FARM POULTRY.

The Poultry Bulletins of the Station being exhausted, and there being a steady demand for information in regard to the housing, feeding and management of poultry, this Bulletin has been prepared to meet this demand. A report is also made of our work in pedigree breeding for egg production which was started last year, a test of the value of green feed and the comparative keeping quality of fertile and infertile eggs.

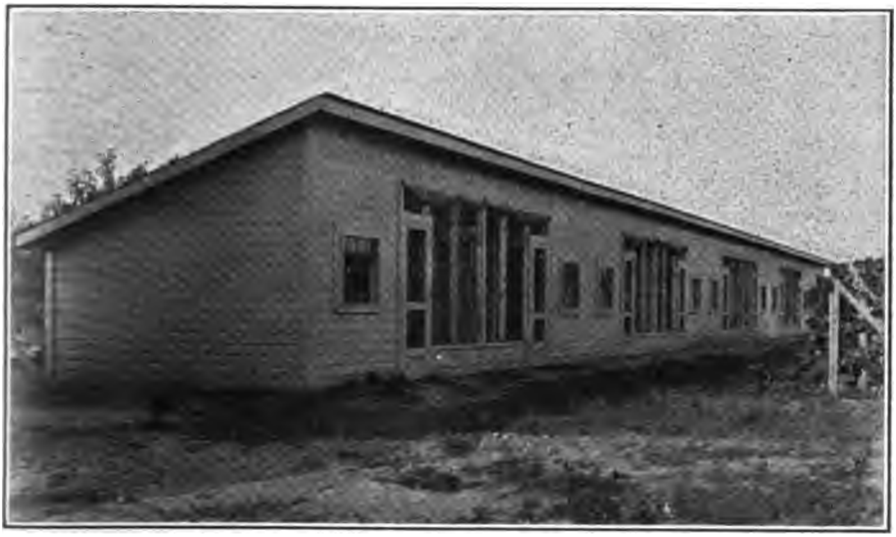


FIG. 1. Scratching Shed House with nine pens. (Photo by Hume.)

HOUSES AND YARDS.

The question of poultry house construction is not so important in our climate as it is in the North where the fowls are confined to the house for much longer periods than they are in the South.

There are, however, some points that must be observed no matter where the location may be, and in a warm climate some points need more attention than they do where it is colder.

In the first place, the house must be dry, and in order to have it dry it must not only have a rain-proof roof, but must be built on ground which has good drainage.

In order that the roof may be rain proof and that it may remain so for the longest possible time, give it a good slope, so that water will run off quickly and not have time to find any small leaks that may occur. It is quite a common thing to see poultry houses built with a roof that has a fall of only a foot or a foot and a half in ten feet, while a fall of four feet in this width would be much better, costing no more to build, and would last years longer than the flat one.

If a place which has natural drainage is not available for the house, it should be set up on posts or some other good foundation, so that it will be well above the ground and filled up with light, sandy soil, and the ground immediately around the house raised so as to turn the water from the house.

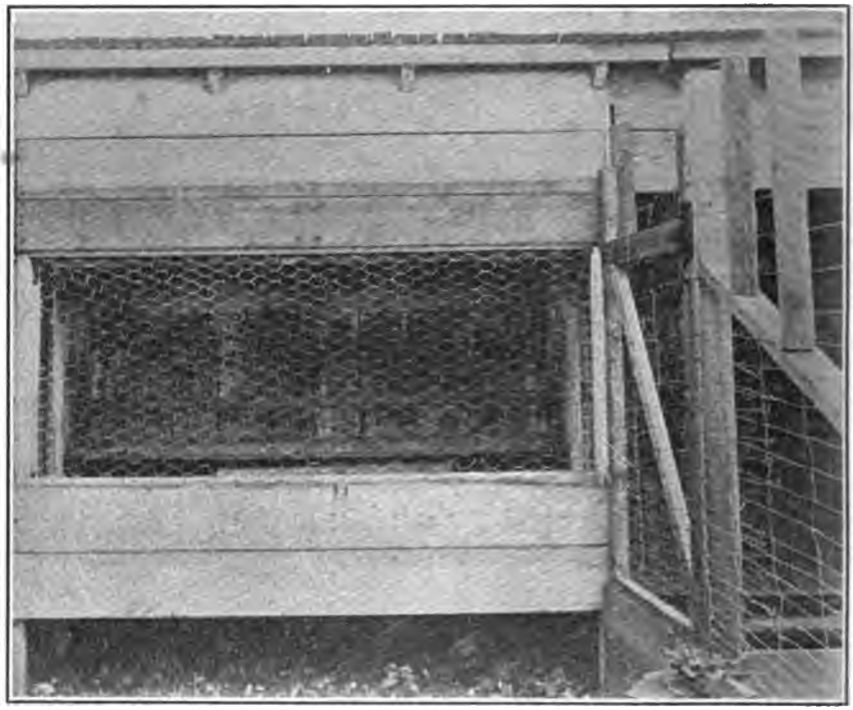


FIG. 2. Wire Front House with Scratching Room underneath. (Photo by Hume.)

Building should be done early enough in the season so that the house and ground will have plenty of time to thoroughly dry out before the fall rains begin or the house is apt to be damp the first winter in spite of all that you can do.

Figures 1 and 2 show two different types of the scratching shed house. In Fig. 1 the scratching shed and roosting rooms are side by side, a close board partition separating them.

In Fig. 2 the scratching room is underneath the house. Fig 1 shows the better arrangement, but is more expensive to build.

Each flock has a house 10 x 18 feet divided into two compartments, giving a scratching room 10 x 10 feet and a roosting and laying room 10 x 8 feet. The cut shows a house of nine pens, but the house may be built with any number of pens desired.

The width of this house, 10 feet, is about right for most poultry houses, as it is not so deep that the sun can not shine to the back of it, and roosts at the back of the house are protected from wind and rain.

Figures 5 and 6 show the interior arrangement of the roosting and laying room, with the roosts hung on stop-lice hangers, a dropping board under them, and the nests under the dropping board.

Fig. 7 shows a corner of the scratching room, with grit and shell box and dry food hopper in position. The scratching litter here is shredded corn stover.

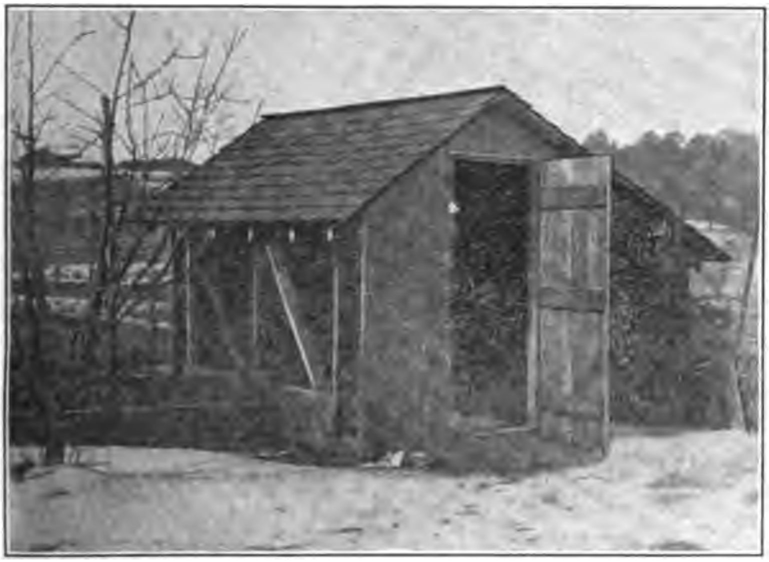


FIG. 8. Wire Front House with Long and Short Pitch Roof. (Photo by MacNider.)

The house shown in Fig. 2 is 6 x 8 feet, and with the roost only five feet from the open front, the fowls are sometimes wet on the roost by a driving rain. Other objections to the house are that it has a board floor and a scratching room into which the sun never shines.

A house 10 x 18 feet, as shown in Fig. 1, requires the following lumber to build: 360 feet ceiling or German siding, 250 feet roofing plank, 2 pieces 4 x 4 x 18 feet, 2 pieces 4 x 4 x 10 feet, 10 pieces 2 x 4 x 12 feet, 4 pieces 2 x 4 x 18 feet, 10 pieces 2 x 4 x 14 feet, and 1,500 shingles or prepared roofing.

A house as shown in Fig. 2, 6 x 8 feet, requires the following: 300 feet plank 1 x 10, 60 feet flooring, 10 pieces 2 x 4 x 16, 10 pieces 1 x 3 for battens, and 500 shingles.

Figures 3 and 4 show two wire front houses, the former 10 x 10 feet for a single flock and the latter 10 x 20 feet, divided into two pens. These houses differ slightly in their construction, but are alike in their essential features. No. 3 is boarded with tongue and grooved ceiling, and has a long and short pitch roof, while No. 4 is boarded with 1 x 10 plank, and the cracks in the back and ends battened. The front of both is made of four-foot poultry wire and planking.

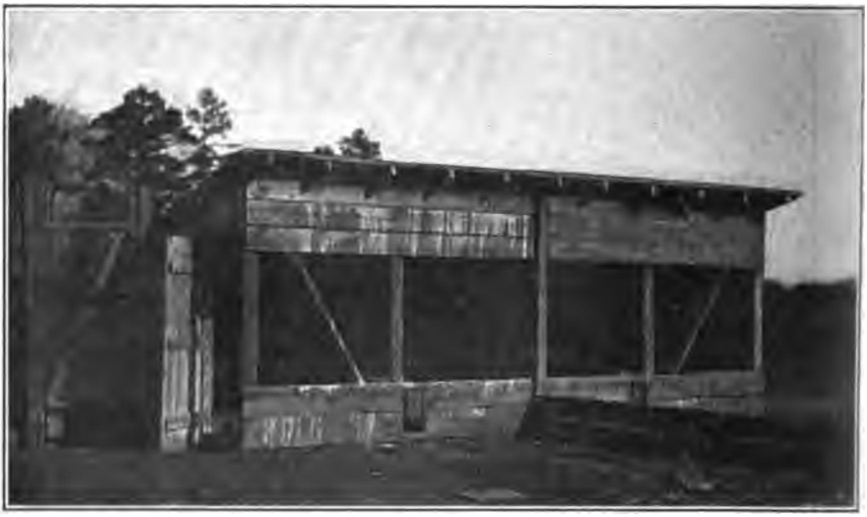


FIG. 4. Wire Front House with Shed Roof. (Photo by MacNider)

No. 4 has the advantage of being slightly cheaper, and is rather easier to build for a man who is not a carpenter. No 3 is built with 5-foot posts in front and 4-foot behind, and is eight feet to peak of roof. It requires the following bill of lumber: 225 feet ceiling, 170 feet roofing plank, 4 pieces 4 x 4 x 10 feet, 10 pieces 2 x 4 x 14 feet, 4 pieces 2 x 4 x 12 feet, 9 pieces 2 x 4 x 10 feet, and 1,000 shingles. No. 4 built 10 x 10, four feet high at back and eight feet in front, will take the following bill: 360 feet plank 1 x 10, 4 pieces 4 x 4 x 10 feet, 16 pieces 2 x 4 x 12 feet, 3 pieces 2 x 4 x 14 feet, 6 pieces 2 x 4 x 10 feet, 16 pieces 1 x 3 x 12 feet, and 900 shingles.

It will be noted that all the houses illustrated are built tight at the back and both ends and left more or less open at the front. The open front should always face the south or southeast. By this arrangement the fowls get plenty of fresh air and sunlight and still are not forced to roost where they are exposed to the wind and rain.

No matter what the style of the house is it should be so arranged that everything can be easily cleared out of it, so that the walls can be thoroughly whitewashed or sprayed, and there will be no unnecessary cracks and corners for lice and mites to hide in.

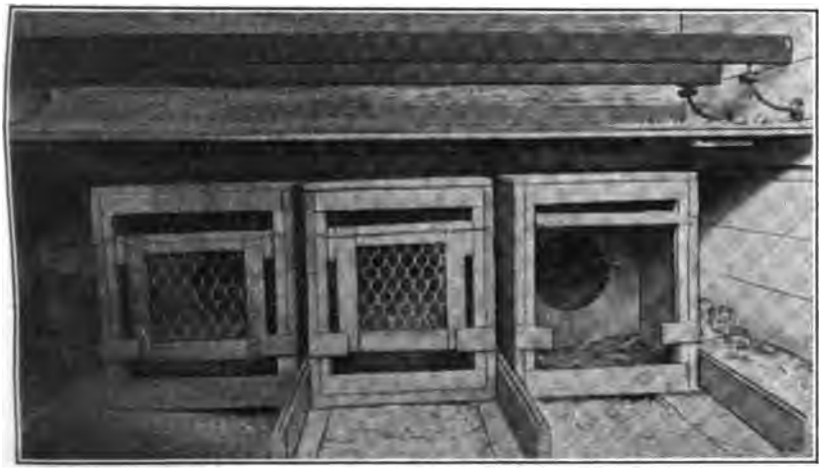


FIG. 5. **Trap Nests.** Two in use and the other set ready for the hen to enter. Also shows arrangement of roosts on stop-lice hangers and dropping board.

A convenient arrangement for the roosts and nests is shown in Fig. 5, and in all cases where the front of the house is open the roosts should be along the back wall as far away from the opening as possible. The dropping board should not be any higher than is necessary for the nests to go underneath it. If the ordinary nest is used 15 inches will be high enough, but if trap nests are used it will need to be 19 or 20 inches from the ground.

Ordinary nests are best made without any top or bottom, the dropping board forming the top and the ground the bottom. Have the nest open to the back of the house and leave room between the ends of the nest and the side walls of the house, so that the hens can pass around and enter the nest from the back. Have a strip along the back of the nest at the bottom to keep the partitions in place and to keep in place any nesting material used. The front of the nest should be hinged to facilitate gathering the eggs. If you have a good sand floor in the house no other material will be needed in the nests and you will thus do away with another hiding place for mites.

The roosts may be made from two by three-inch pieces set on edge and the top edges slightly rounded. They may be set on Stop-lice hangers, as shown in Fig. 5, or dropped into slots cut in boards attached to the dropping board, so that they will be about six inches above the board. In this latter case the dropping board should not be supported by the walls of the house, but should be set up on benches of the proper height and made so that it will not touch the wall at any place. In either case the roosts should be cut short enough so that they will not reach the walls at either end. This arrangement makes it difficult for the mites to pass from the walls to the roosts.

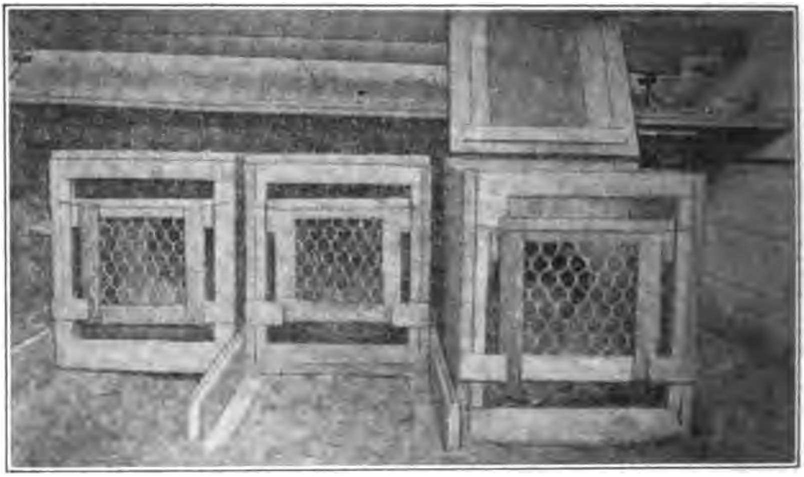


FIG. 6. Trap Nests, showing one drawn forward and top raised to remove hen after laying.

In estimating the capacity of the house it is well to be on the safe side and not overcrowd. This is especially true in regard to breeding stock from which you wish to hatch good, thrifty chickens. Any of the houses shown by Figs. 1, 3 and 4 are large enough for a pen of ten or twelve breeding birds, or if eggs for market only are wanted they will accommodate twenty-five hens.

It should always be remembered that the more crowded the fowls are the more precautions must be taken to keep good the sanitary conditions.

If the fowls are to be confined in yards most of the time, the yards should be large enough so that a green crop can be kept growing all the time. This can be better done where the yard is divided, as in this way the fowls can be kept off the crop till it has got a good start. If the fowls have farm range and a yard is only needed for the breeding stock while eggs are wanted for hatching, it need not be so large, as the crop can get a good start before the hens are put on it, and then will last for the time that the breeding is done. After the breeding season, the hens should be turned out with the rest of the flock, and the yard will make a good place to confine the male in till he is needed for breeding purposes again.

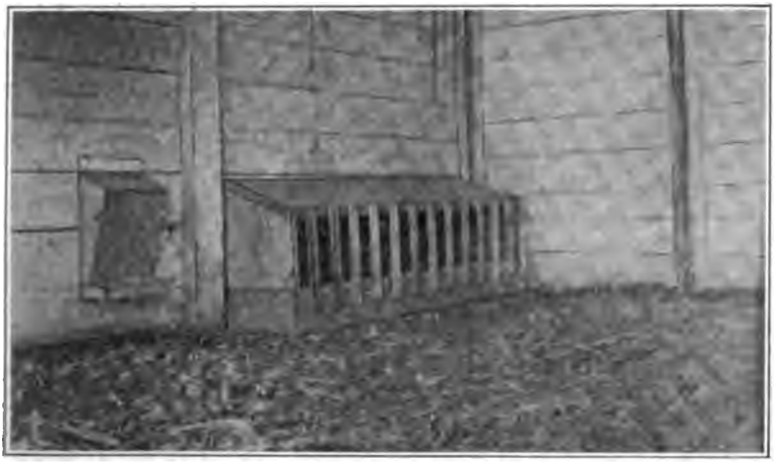


FIG. 7. A corner of the Scratching Shed, showing dry food hopper and grit and shell box.

BREEDS OF FOWLS.

It is not my intention to attempt to describe all the different breeds of fowls, as that would take more time and room than can be given to it in this Bulletin, so I will only give descriptions of the varieties kept at the Station. Anyone wanting a fuller description should procure a copy of the American Standard of Perfection, which gives ideal cuts and detailed descriptions of all standard varieties of fowls, ducks, geese and turkeys.

As previously stated, the cuts shown here are made from photographs of birds in our breeding pens, and in most cases give a good idea of the quality of the stock, but in a few cases do not do justice to the birds represented, as it is difficult to get a good photograph of a bird that is not coop trained and accustomed to handling.

PLYMOUTH ROCKS.

The Plymouth Rocks are the most popular of all the breeds for the farm. This is especially true of the barred variety, they being the oldest variety of this breed and the one most commonly seen on the farm. In fact, their popularity is so great in many sections that to say Plymouth Rocks means the barred variety. The good points which have made this variety so popular can be found in either the buff or white varieties, and from a market standpoint these lighter colored varieties have advantages over the darker barred variety. All varieties are fairly hardy, good winter and fair summer layers, and are good sitters and mothers. They lay brown-shelled eggs and have the yellow legs and skin, which most markets prefer.

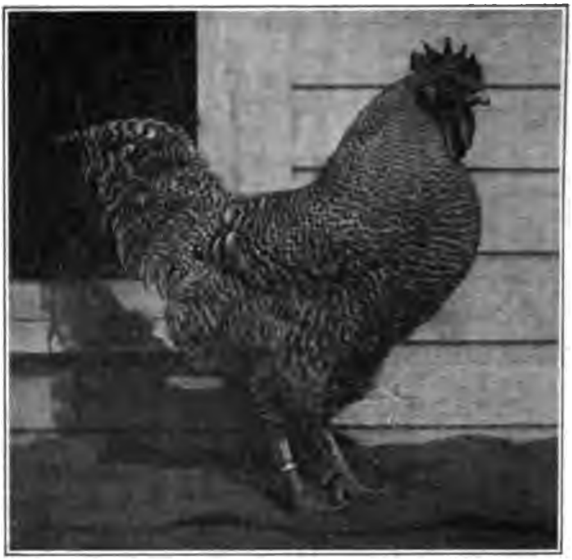


FIG. 8. A Barred Plymouth Rock Cock. A medium colored bird of good size and sha
(Photo by MacNider.)

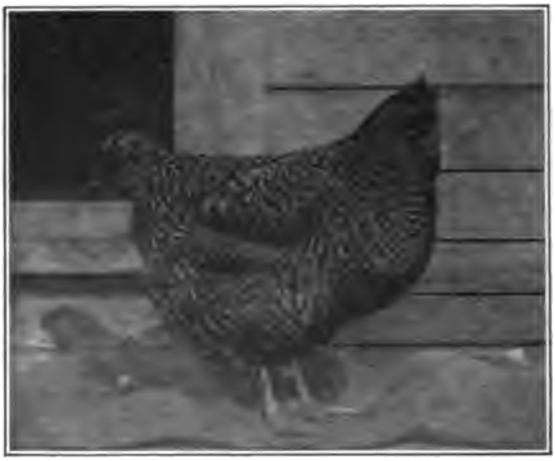


FIG. 9. A Barred Plymouth Rock Hen that has been a winner in some of the best show
in the country. (Photo by MacNider.)

Standard weights for all varieties are: Cock 9½ pounds, hen
pounds, cockerel 8 pounds, pullet 6½ pounds.

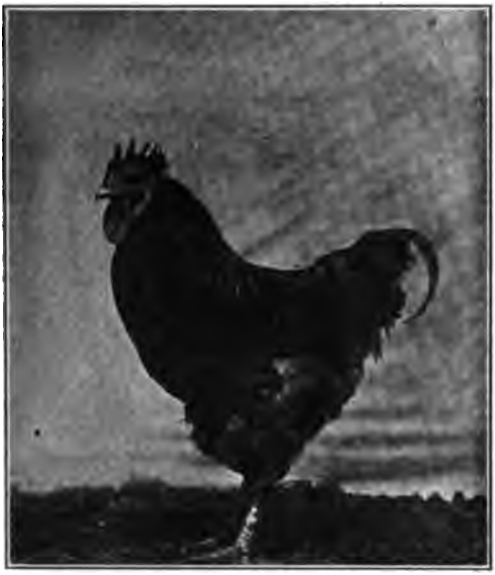


FIG. 10. A Buff Plymouth Rock Cock of excellent shape and color.

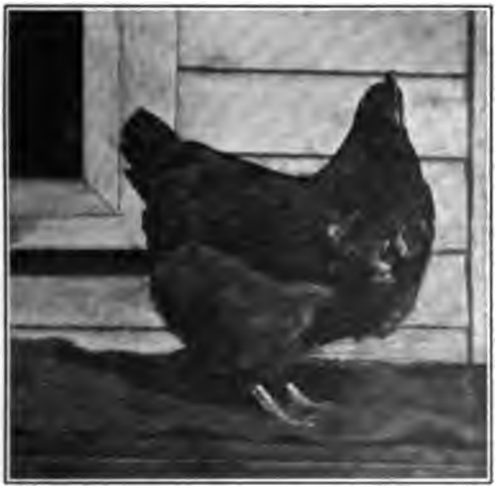


FIG. 11. A Buff Plymouth Rock Pullet, No. 6028. (Photo by MacNider)

WYANDOTTES.

In the Wyandottes we have more varieties and therefore a wider range of choice in the matter of color. The varieties we keep are the white and buff.

The white, although not the oldest variety, are the most popu and for the last few years have been one of the largest classes Fairs and Poultry Shows.

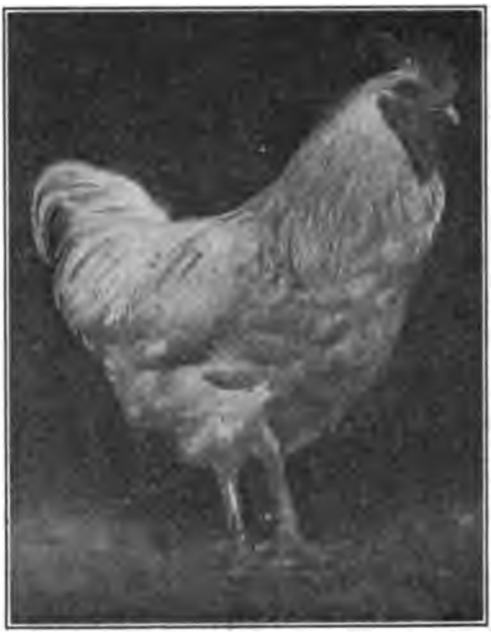


FIG. 12. A White Plymouth Rock Cockerel. (Sold to N. C. Department of Agriculture for their Edgecombe County Test Farm.) (Photo by MacNider.)

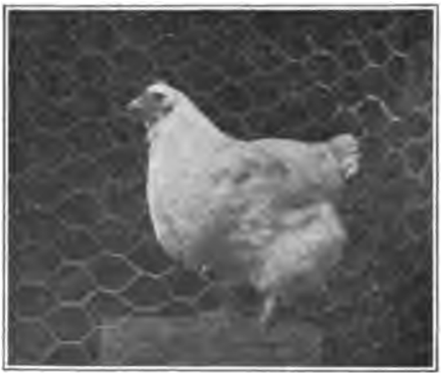
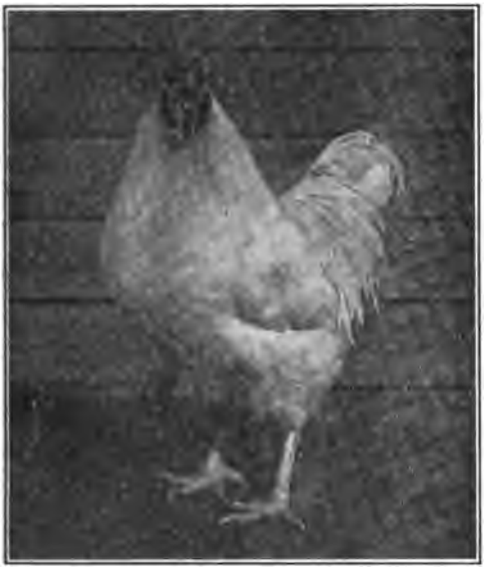


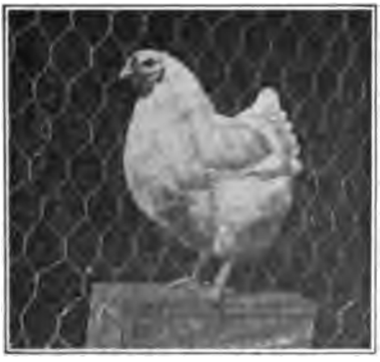
FIG. 13. A White Plymouth Rock Hen of good shape and absolutely white.

The Wyandottes have the same general characteristics as the Ply mouth Rocks, but are smaller and more blocky. They are quick ma turing and make first-class broilers or medium-sized roasters. Al varieties have the rose comb. They are good winter and fair summer layers, are good setters and mothers, lay brown-shelled eggs and have yellow skin and legs.

Standard weights are: Cock 8½ pounds, hen 6½ pounds, cockerel 7½ pounds, pullet 5½ pounds.



IG. 14 A very typical White Wyandotte Cock of good color. (Photo by MacNider.)



IG. 15. White Wyandotte Pullet. Note the neat head, full breast, short slightly cushioned back and well spread tail.

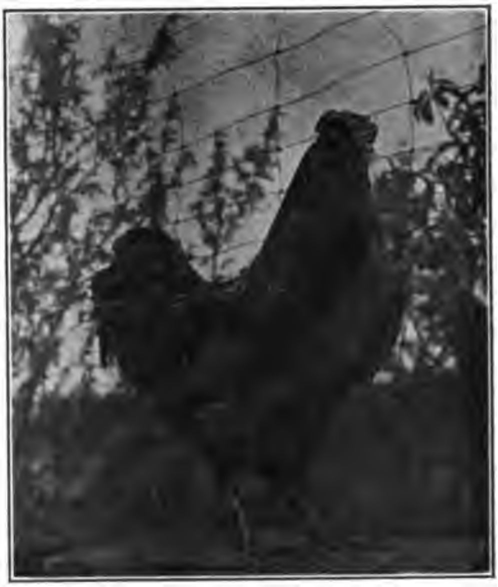


FIG. 16. A Buff Wyandotte Cockerel of good style

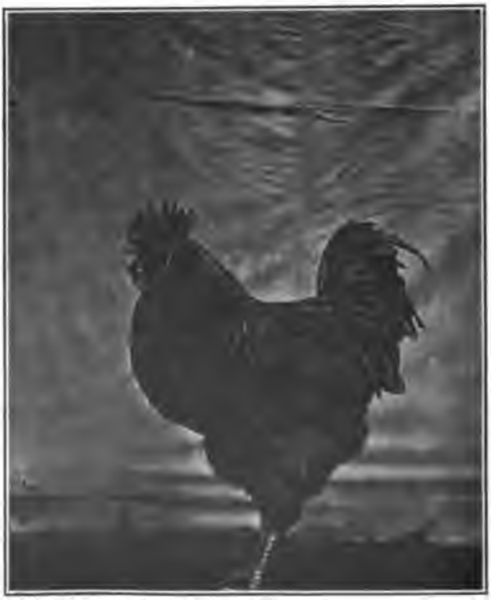


FIG 17. A Buff Orpington Cockerel of sound color and good shape.

ORPINGTONS.

There are several varieties of this breed, but the Single Comb Buff are by all odds the most popular and the most commonly kept, and are the only variety that we keep.

They are a comparatively new breed, of English origin and were first brought to this country in 1898 and were admitted to the Standard in 1902. They are the largest of what may be called the general purpose breeds. They are fairly hardy, good winter and fair summer layers, are good setters and mothers and lay brown-shelled eggs, but have white flesh and legs. The chicks grow and feather rapidly and make good broilers and roasters.

Standard weights are: Cock 10 pounds, hen 8 pounds, cockerel 8½ pounds, pullet 7 pounds.

LEGHORNS.

This breed has also a number of varieties, but those most commonly seen are the Single Comb White and Brown.

The Leghorns are classed as one of the egg breeds and are, as a rule, prolific layers, especially in warm weather. My experience has been that they do not do as well as some of the heavier breeds, such as the Plymouth Rocks and Wyandottes, during the winter, and are more susceptible to weather changes, a cold snap checking egg production much more in them than in the heavier fowls.

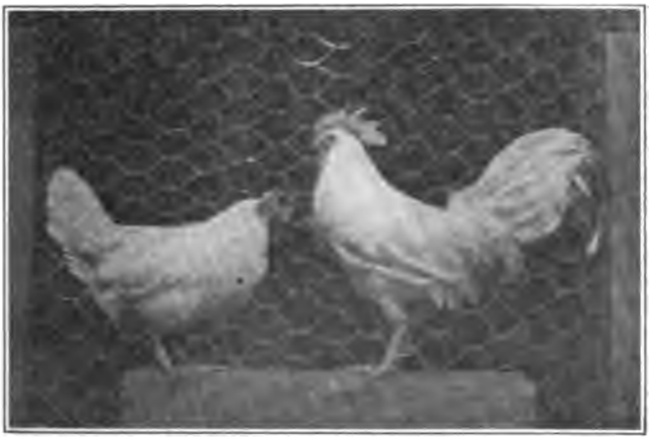


FIG. 18. White Leghorn Cock and Hen. Birds of good shape and color and the hen a good layer of extra large eggs.

The white, as a rule, lay larger eggs than the browns, due, no doubt, to their having been more carefully selected and bred for this point, as they are largely used to supply the New York market, which pays a premium for large, white-shelled eggs.

There is no standard weight for the Leghorns, but size is of importance and is recognized in the Standard, eight points being allowed for this point. A large strain of Leghorns make good broilers as well as good layers, if the demand is not for a very large broiler, as they feather quickly and for the first three months make rapid growth.

MINORCA.

The Minorca is the largest of the egg breeds and the only one that has a standard weight. They are good layers of extra large eggs, and where a premium can be had for extra large eggs will make a good fowl to keep, but my experience has been that they are not as economical producers as the Leghorn.

Standard weights for the Single Comb Black are: Cock 9 pounds, hen 7½ pounds, cockerel 7½ pounds, pullet 6½ pounds.

LIGHT BRAHMA.

This is the largest breed of poultry, and where large roasters or capons are wanted they will answer well, but on account of their large size and slow maturing they are not well adapted to the production of broilers and small roasters. On account of their feathered legs they are not well liked by many for our warm climate.

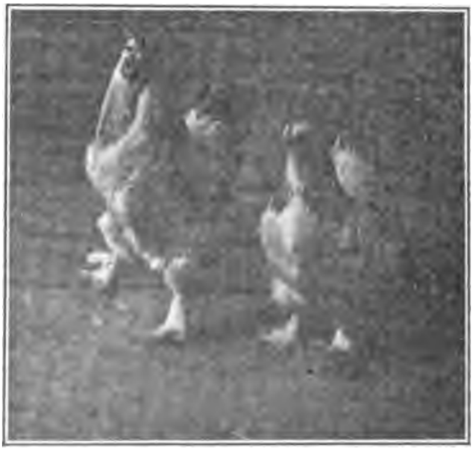


FIG. 19. A Fine Light Brahma Cockerel and Pullet.

They are fairly hardy, fair winter layers and only fair as sitters and mothers as, on account of their large size, they are often clumsy and are apt to break the eggs and crush the chicks.

Standard weights are: Cock 12 pounds, hen 9½ pounds, cockerel 10 pounds, pullet 8 pounds.

PEKIN DUCKS.

The Pekin may justly be called the market duck of America, as they are used for this purpose almost exclusively on the large duck ranches. They are hardy, fair layers and mature quickly. As a rule, they do not become broody and hens or incubators must be used to hatch the young.

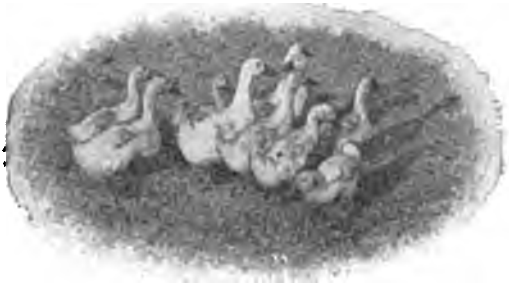


FIG. 20. Pekin Ducks five weeks old. (Photo by Hume.)

When raised for market they should be forced from the start and marketed as soon as fully feathered, which is usually at about ten weeks old. If kept longer the profit is not so large, as they moult soon after this time, and most of the food goes to the production of feathers instead of meat.

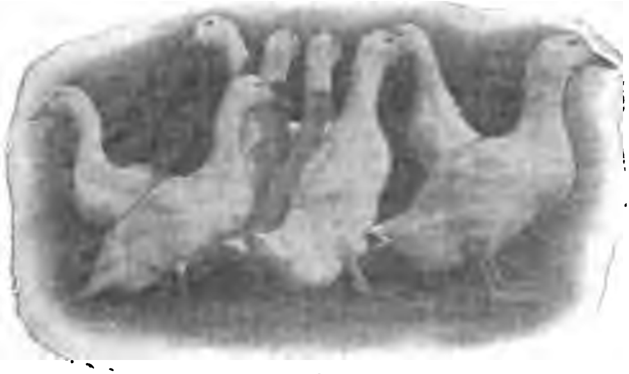


FIG. 21. The same Ducks three weeks later.

It is an advantage to have water for the breeding stock, as the eggs are usually more fertile under these conditions, but it is not absolutely necessary, as fair success can be had without water except a plentiful supply for drinking purposes. The young ducks will grow faster and fatten better if kept away from the water.

SELECTING THE BREEDING STOCK.

Many think that if they are going to do anything with poultry they must have several different varieties. For the farm they could hardly make a more serious mistake. In the first place, where more than one variety is kept, the fowls must be confined or they will cross, and you will soon have no pure bred stock. If you have to confine your fowls you lose one of the greatest advantages that the farmer has in keeping fowls, as when they have free range they will find a large proportion of their food which would otherwise go to waste.

Secondly, if you have several varieties, you lose that uniformity of your product which is desirable either in your poultry or eggs.

Perhaps the most common mistake made by farmers in their breeding of poultry is that they breed from all the hens in the flock without any pretense of selection. Our progressive farmers are all wide awake to the necessity of seed selection if they want to get the best returns from their field crops but few have thought it necessary to carry this matter of selection to their poultry where it will give just as good returns as in any other crop raised on the farm.

In selecting breeding stock the first consideration should be given to constitution and vigor. Without this neither male or female will ever be a success in any branch of poultry work. A cock who is always on the move, calling the hens and scratching for them, whose crow is the loudest, the first to be heard in the morning and the last at night, is not apt to be lacking in this respect. If in addition to this you have a bird that is well set up on good stout legs placed well apart, with a full well-rounded breast, a broad back with the width carried well back to the tail, a stout neck, not too long, and a broad head and full, bright eye, you have one that is all right to head your pen, no matter what his breed may be.

The females should have the same general characteristics.

Watch the hustlers. The hen first down from the roost in the morning and last up at night, always on the hunt for something to eat, is the one that is likely to give you the eggs. The one that gets off the roost when you come to feed and sits around after being fed is more than apt to be a drone in the flock.

Select as many of your best hens as you think will be needed to raise as many chicks as you want and mate them with a cock such as described, giving them a small house and yard to themselves for the breeding season and you should make good progress in the improvement of your flock.

If you need more hens than one male can attend to, have two males and run them with the hens on alternate days to avoid fighting. It is always better to have too few rather than too many hens with the male. I have found on several occasions that I could reduce the number of hens in the pen and increase the number of chicks from the pen.

Fowls in their second year are generally the best for breeders, and you then have the advantage of being able to select those that have been the best performers in their first year. There would be no objection to occasionally using a well developed pullet in the pen if she had some point of excellence in a marked degree and if you mate her with a cock, but the practice of continually breeding from pullets and cockerels will almost, without exception, end in a deterioration of the flock.

FEEDS AND FEEDING.

In most places in the South the condition of high-priced feeds has to be faced, and it is not likely there will be any change in this condition as long as we have to depend on the Northern and Western States for a large proportion of our supply.

Let us divide the feeds into three classes, viz, Grains and their products, Green feeds and Animal feeds.

For grain food we have to depend almost exclusively on the following: Corn, wheat (mostly screenings), and oats.

We feed considerably more corn than all the other grains put together, because it is the cheapest feed that we can get and we can get it at all times, which we can not say of the other grains, at least at a price that would admit of their being fed to poultry. All our corn is fed either as cracked corn or corn meal. We feed no whole corn at all. Corn is a carbonaceous food, supplying heat and fat-producing materials in excess of the wants of fowls under most conditions, but by combining it with green and animal food we are able to use it quite largely and make it the base of our ration. On account of the large size of whole corn the fowls can get a feed of it with practically no work, and it is to get over this condition that we crack it. Fed in this way in litter where the fowls have to scratch for all they get, it can be more liberally fed without the fowls becoming over fat from it.

Wheat is generally conceded to be the best one grain for poultry. It contains food elements in very nearly the proportions that fowls need them. In this neighborhood it is not often that good wheat can be bought at a price that will allow of its being used for poultry feed. Good wheat screenings, when they can be got, are almost as good as milling wheat for poultry feed, but this will not apply to samples that are largely made up of chaff and weed seeds. It is more important to buy screenings by weight than sound grain, as it will not weigh as much to the measured bushel, and if bought by the measure one often pays as much for it as for good milling wheat.

Oats of good quality contain about the same food value as wheat, but on account of the coarse husk are not as well liked as wheat or corn. Fed either ground, or soaked in water for some hours, they are eaten better. They are specially good for feeding to growing breeding stock.

Corn meal, wheat bran and ground oats are used in making our mash. It is important that the fowls have an abundant supply of green food at all times if they are to do their best. I have often thought that the Southern farmers and poultrymen are not making the most of the advantage they have in a mild winter by having a growing crop of some kind for their fowls to run on. The value of the green food comes quite as much from the action it has on the digestive system, toning it up and keeping the fowl in good health, as from its actual food value. It seems to be specially necessary and beneficial where we depend largely on corn in our ration.

We have used several crops for winter green food, some of the best being rye, rape and salad turnip.

Rye is, I believe, the best all round crop for this purpose, as it is quick growing and stands pasturing by the fowls well, and if not pastured too heavily will last from October till the middle of May, giving good grazing all through the winter in our average winter.

Rape and turnip make good grazing for a while, but my experience has been that they do not last as well as the rye, and they are harder to grow, requiring better land and a better preparation than for rye.

Clover makes a fine crop for this use, but is not so certain of making a stand as the other crops mentioned.

In sections where cabbage is grown the heads that are not marketable can often be had for the hauling or at a merely nominal cost and make a good winter feed.

THE EFFECT OF GREEN FOOD ON THE FOWLS.

In order to test the effect of green food on fowls enough hens to eat out completely all the rye in one pen were put in during the fall. Then two lots of Barred Plymouth Rocks, as nearly alike in age and condition as possible, were mated. One lot was put in the pen from which the rye had been removed and the other in a similar pen alongside of the first and which had a good stand of rye in it. The housing and feeding of both pens were the same except in the matter of the green food.

Below you will find recorded the number of eggs laid by each pen for the months of February, March and April:

	With Rye.	*Without Rye.*
February	71	65
March	86	82
April	83	30
	240	177

This shows an increase of 63 eggs in favor of the fowls having the green feed. The feed of both pens was a mash composed of equal parts of corn meal and wheat bran with 10 per cent of beef scrap added; for grain they had cracked corn and wheat screenings in the proportion of two parts of corn to one of wheat. Early in April our supply of wheat screenings was exhausted and, being unable to get any more, both pens had no grain except cracked corn. Before the end of April the fowls without rye went badly out of condition and three of them died from indigestion and liver trouble. The balance of the flock were turned out on grass and have come round all right. These were the only cases that we had of indigestion this spring, although all our fowls were fed the same food with the addition of green food of some kind.

I think this case indicates very clearly the value of green food, especially when used in conjunction with a ration made up largely of corn.

ANIMAL FOOD.

Animal food may be supplied in several different forms; the most common probably being some of the commercial feeds put out by the packing houses, such as beef scrap, meat meal, blood meal and digested tankage.

The advantage of these feeds is that they will keep well in almost any climate as long as they are kept dry, and are ready for use at any time. The only objection to them is their cost, which is higher than green cut bone.

Green cut bone, if obtainable, is probably the best source of animal food as well as the cheapest. The objections to it are the difficulty in getting a regular supply of perfectly fresh bones and the work in preparing it for the fowls. In many places bones can be got from the butcher for one-half cent per pound, and at that price are cheaper than commercial feeds; but it is necessary to have the bone fed to the fowls while fresh, and this in summer means that the bone must be fed the day that it is cut. If allowed to become tainted it is dangerous to the fowls and had better be thrown away than fed in that condition.

Skim milk is a source of animal food that is often overlooked in poultry feeding, and where it is available is often used for other stock when it could to better advantage be used for the hens and growing chickens. Our own experience as well as that of others has been that milk is a very valuable addition to the ration for laying hens, especially in summer.

The general practice among poultrymen is to feed part of the ration in the shape of grain, either cracked or whole, and part as a mash. The advantage of the mash is that by mixing the feeds the hen is obliged to eat them in the proportions in which they are supplied and the ration can in that way be balanced to the needs of the hen for egg production or for whatever you are feeding and not to suit her individual taste. The question to-day is not whether to feed a mash or not, but how to feed the mash.

Until recently the common practice has been to mix the mash with water or milk and feed in a wet, crumbly condition in pans or in a trough.

The difficulty with this method has been that some of the hens would gorge themselves with this wet mash, which they could gulp down quickly, and if the quantity was not ample for all some would get too much and some not enough, the former suffering in time from indigestion and the latter never getting enough to allow them to make a satisfactory egg yield.

Recently some have been advocating the feeding of the mash dry, claiming that it was a more natural method and that the fowls fed this way were not so liable to digestive troubles, as on account of the mash being dry it could not be swallowed as readily as the wet mash could, and that the hens took longer in feeding, and that the food was better mixed with the digestive juices and not so liable to sour in the crop and cause trouble. From this beginning some have developed a system of feeding in which they feed only once a week, using hoppers to hold the feed, so that it will always be before the fowls and at the same time being so constructed that the fowls can not get into them and waste the feed. Some use the hoppers for the mash only, still feeding the grain in litter at stated times, and others feeding the entire ration from the hoppers, allowing the hens access to the food at all times. This latter seems to give good results for fowls on range and for growing stock also on range, and it can be seen at a glance that by this system the expense of the labor for feeding is cut to a minimum. Whether it would be as satisfactory or not for fowls in confinement I am not prepared to say, as I have not tried it; but for the last four months most of our breeding stock have had the mash part of their ration dry in hoppers before them at all times and while we have not tried the system long enough to say positively that it is better than the wet mash method, as far as we have gone it has been a success and it is certainly a considerable saving in labor to feed even the mash in this way.

Fig. 7. shows the feeding box that we use in the breeding pens. This is made with the top hinged so that it can be raised to put the feed in. It has two compartments, one three feet long and the other one foot long, the former for the mash and the latter for beef scrap. Our breeding stock gets a feed of grain in litter the first thing in the morning and can help themselves to the dry mash at any time that they care to. There is no crowding at the feed box the way there was at the trough when the mash was fed wet and all given at one time during the day. The hens will take a few mouthfulls of mash and then go for a drink or to look for a stray grain of wheat or corn, and then back to the feed box again till they are satisfied. In this way a much larger part of their time is taken up with their feeding and they have less time to get into bad habits, such as feather pulling and egg eating.

The feed box shown is only open at one side and is intended for use in the house only, but by having the slats on both sides and the cover made sloping from the middle to both sides and extending far enough over the sides to protect the contents from rain it would answer well for outside use for growing stock.

EGG PRODUCTION.

When we come to the matter of egg production and the selection of breeding stock for that purpose, the suggestions made previously are all right as far as they go, but for this work we must go further and consider the performance of each individual hen. This can only be done by the use of trap nests.

This work was first started in February, 1906, and while we did not find any extraordinary layers among our stock, we found some good ones, and also some that certainly were not earning their board. After keeping the records for two months we cut out all the Barred Plymouth Rocks but four, keeping the same number of the white variety and only one of the buff.

Shortly after making the selection we were unfortunate enough to loose one of the barred hens that gave promise of being the best layer in the lot (No. 5118), and this without getting any chicks from her, as all her eggs that were incubated were infertile. Later in the season we lost, by an accident, the next best one of the four (No. 5113), but in this case we secured three pullets from her. These pullets were June hatched and did not develop early enough to begin laying till the end of February. Only one of the three (No. 6076) has so far shown any signs of having inherited her mother's laying qualities.

Records were kept last year for only four months, from the first of February till the end of May. This year we will keep the records for the entire year.

Below are given last year's records of the hens mentioned as being reserved for this year's work. In addition to these we had the best of the pullets raised last spring.

FIG. 22. Barred Rock Hen No. 5110 (cockerel bred). One of our best layers.

FIG. 23 Barred Rock Pullet No. 6076. A daughter of No 5118, and a promising layer.

	Feb.	March.	April.	May.	Total.
Barred Rock, No. 5110....	19	13	11	11	54
" " " 5111....	3	21	11	12	47
" " " 5113....	9	18	20	16	63
" " " 5118....	17	26	3*		46
White " " 70....	17	19	11	12	59
" " " 5135....	19	19	15	15	68
" " " 5137....	10	14	13		37
" " " 5138....	14	18		13	45
Buff " " 5128....	3	17	13		33

*Became broody after laying 46 eggs in 54 days; was broken up, but died on the 9th April.

Below are given the records for the first four months of this year. It will be noticed that out of the five hens now in the pens that were in last year's records, four have made better records this year than they did last. This it is thought is due to the change in the manner of feeding noted above. As the Buff Rocks were not mated up till January 21st, their records are only given for three months. The four pullets, Nos. 6162, 5052, 6028 and 6163, are all daughters of No. 5128. No. 5128 and 6162 both became broody early in April and did not begin to lay till after May first. No. 6028 died March 16th. As has been previously stated, No. 6076 was late hatched and did not start to lay till the end of February, so her record for March and April only are given.

	Jan.	Feb.	March.	April.	Total.
Barred Rock, No. 5110....	16	8	23	11	58
“ “ “ 5111....	18	16	16	12	62
“ “ “ 6076....			24	18	42
Buff “ “ 5128....		14	20	5	39
“ “ “ 6028....		19	10		29
“ “ “ 6162....		20	18	4	42
“ “ “ 5052....		17	23	18	58
“ “ “ 5163....		14	23	19	56
White “ “ 70....	12	9	14	15	50
“ “ “ 5137....	19	17	11		47
“ “ “ 6145....	2	18	19	18	57

The trap nests (Figs. 5 and 6) used are of the same design as those used at the Maine Agricultural Experiment Station. Fig. 5 shows two of the nests occupied by hens and the other set ready for the hen to enter. Fig. 6 shows the third nest drawn forward and the top raised to remove the hen after she has laid.

We have found this style of nest very satisfactory and have had little trouble in getting the hens to use them. Occasionally, however, we have a pullet that refuses to lay in them, but by closing up the space shown at the ends of the nests, so that the hens can not get behind or in the corners to hide their nests, we have little trouble in this way.

COMPARATIVE KEEPING QUALITY OF FERTILE AND INFERTILE EGGS.

The farmers of the South suffer a heavy loss every summer on the eggs that they sell on account of the poor condition in which these often reach the market. It is such a natural condition that in warm weather any product of this nature should deteriorate quicker than it does in cool weather that many people have accepted the loss as unavoidable and made no effort to remove the cause of it.

The fact that an infertile egg will stand a temperature of 103 degrees for ten days and still be fit for use as food, although of course not equal in quality to a new laid egg, should point us to a remedy for a large part of the trouble with eggs not keeping in hot weather.

A fertilized egg is a living organism, and all that is necessary to start the growth of the germ cell is heat, and while 103 degrees is the best temperature for incubating the egg, it is well known that the germ will begin to develop at 90 degrees if this heat is continued for a few hours. It is no uncommon thing for the temperature to run this high for days at a time in summer, and unless care is taken to keep the eggs in a cool place, such as a cellar, they are sure to be injured. Even if they are so kept and leave the shipper in good condition, they are often ruined in shipment, as a short time on a railway platform in the sun will do the mischief. Then when night comes the temperature drops and the germ dies, and where death occurs putrefaction always follows.

From this it will be seen that the fertilization of the egg is largely responsible for the loss of eggs in warm weather. Therefore, if we can prevent eggs from being fertilized we have removed the principal cause of the trouble, and as this can be done by simply removing the males from the flock, there is no reason why any one should put up with loss from this cause.

In order to ascertain just what the difference would be between the fertile and infertile eggs, when we were done hatching last season we left the males in three of the pens, removing them from all the rest. After ten days we put up all the eggs from the pens in which the males had been left and at the same time put up an equal number from the pens from which the males had been removed. These eggs we intended to keep in a room upstairs where they would be under the average conditions under which eggs would be kept throughout the country. Rats destroyed some of them, and we were obliged to put them in the incubator cellar, which was comparatively cool and the conditions were decidedly favorable to the fertile eggs. The eggs were gathered for two weeks and all then stood for a week, after which all were broken and examined.

Of those from the pens where the males were, 15 per cent were bad and the quality of the balance was not as good as that of the infertile lot. In the infertile eggs there were none bad, and while some were slightly shrunken the general quality was good.

INCUBATION.

The hen is still the most commonly used incubator on most North Carolina farms, but there is no doubt that artificial incubation is in much more general use now than it was a few years ago. Our rapidly increasing population, with more money at their disposal, has created a demand for poultry and eggs greatly in excess of the supply, and there has been, as a result, a marked increase in the price of these products. As the price has advanced farmers have been more anxious to supply the demand, and a great many have looked to the incubator to help increase their stock of chickens.

Where one wants only a few chickens and there is no special demand for them early in the season, the plan of hatching by hens will answer very well. There has been no incubator manufactured to date that will do better work than a good, reliable, broody hen, but, unfortunately, all hens do not make reliable setters.

In keeping track of the eggs put under hens and those in my incubators, I have on different occasions, when I had a number of hens set, found practically no difference in the percentage of chicks hatched by the two methods. I have always had some hens that would hatch a larger percentage than I have ever been able to get from the incubator, but, on the other hand, I always have some eggs broken by the hens, and occasionally a hen will leave the nest and ruin the whole of the eggs given to her.

Whether it will pay to use an incubator depends not only on the market that is available, but to a certain extent on the person who is to look after the machine or the hens. A person who has a natural liking for working with the hens and has no mechanical turn is apt to do better work with the hens. There are several makes of incubators now on the market that any person of average intelligence can operate successfully, even from the first, if he will follow carefully the instructions sent with the machine.

A great many are disappointed with the results that they get with their incubators, because they expect too much. Having read of 95 per cent to 100 per cent hatches, they expect to get them from the start, while experienced poultrymen are well satisfied if their hatches run from 75 per cent to 85 per cent of the fertile eggs. Why the balance of the eggs which are fertile and often have well grown chicks in them do not hatch is a disputed point, some claiming that the trouble is in the machine and others that it is in the eggs or the stock that produced the eggs. I expect that both are sometimes to blame. The introduction of trap nests has shown me in two seasons work that I have some hens whose eggs will almost every one give a live chick, either in the machine or under a hen. There are some that will hatch well under a hen but not so well in a machine, and others whose eggs will not hatch by either method. All these hens were fed and cared for in the same manner and, in some cases, the two extremes come from hens in the same breeding pen.

The most striking example that we had last year of the eggs hatching well in both tests was the Buff Rock hen, No. 5128. Almost every egg from this hen that was incubated gave a chick, and the chicks were unusually strong and vigorous. It was on account of this quality that this hen was selected from all the Buff Rocks of last year to be used this year as a breeder. A reference to the remarks on pedigree breeding for egg production will show what the hen and her daughters have done as egg producers. When I add that a son of hers went through five of the best shows in the South last fall and winter and came out with five blue ribbons to his credit, and that her daughters divided four of the five firsts at these shows between them, it will be seen that her selection has been amply justified. I mention the matter of the shows because it requires birds of stamina and vigor to make show birds of the best quality and to stand the strain of showing for any length of time.

On the other hand, the Barred Rock hen, No. 5118, never gave us any eggs that would hatch. These two cases show that there is as much difference between hens in the matter of laying eggs that will hatch, as there is in the number of eggs that they will lay in a season. Much can be done by careful selection of the breeding stock to avoid the very annoying experience of finding a large number of chicks dead in the shells when the hatch is over.

The thorough disinfecting of the incubator before each hatch will also, I believe, give some relief from this trouble. One bad egg in a lot will contaminate those near it, and it is quite a common condition to find at the end of the hatch some eggs in which the chicks have died and putrefaction has set in. The germs from these eggs remain in the incubator and attack the fresh eggs put in for the next hatch, weakening the vitality of the chick, in many cases so that it dies in the shell, and those that do hatch start life with a handicap from which they never fully recover. The fact that new machines often give better results the first hatch than can ever be got from them again, and that the first hatch at the beginning of the season often gives stronger chicks than can be got later in the season, even with a higher percentage of fertility, seems to indicate that the sanitary conditions in the machine are not as good after a few hatches have been run as they were at first. For this disinfection I would recommend one of the coal tar products such as Creolin Zeuoleum or Chloro-Naptholeum, using a five per cent solution.

One great advantage of the machine is that it is always ready to use. What is more annoying than to have plenty of eggs from the hens that you want to hatch from and not a broody hen to hatch them? A greater number of eggs can also be hatched with the same work in incubators than with hens, and the chicks have the advantage of being hatched free of lice, which is an important consideration in our warm climate. Again, where the incubator is used, the hen can be kept at work producing eggs instead of hatching them. It is not often difficult to break up a broody hen, especially early in the season, if she is taken from the nest as soon as she becomes broody and put in a strange pen where there is no nest. I have frequently had a hen back in the breeding pen and laying in a week's time. But the sooner they are moved after they take to the nest the easier it is to break them.

If this plan is followed for a few years it will be found that the hens will become less and less addicted to the habit of setting and will be easier broken from it when they become broody.

When hens are used for hatching they should always be moved from the hen house and put where other hens can not bother them. There is little danger of breaking up the hen if she is moved carefully after dark. I prefer to make the nest on the ground, using the skeleton nest referred to previously, laying a plank on top and throwing a sack over the front for a day or two till the hen becomes accustomed to the new quarters, when both sack and plank may be removed. Hollow the earth slightly and make the nest with soft hay or straw.

The hen should have a good dusting with insect powder two or three times during the hatch, the last time just before the eggs are due to hatch. If the hen has to be covered up at the first it is better to delay the first dusting till the cover is removed, as some of the lice powders now on the market are so strong that they will injure the hen if freely used on the hen when closed up in a small space. If a number of hens are set in the same place it is best to remove them once a day for feeding and see that they get back on the nests again, otherwise two may take to the same nest and let a lot of eggs get chilled.

Many people do not use an incubator because they think that they have no place suitable in which to run it, thinking that in order to get good results a special incubator house is necessary. The fact is, that incubators are successfully operated in about as many different kinds of places as those in which hens are kept. If several machines are used it will be better to have places that are not used for any other purpose. The best conditions for artificial incubation are a fairly even temperature, good ventilation without drafts, sufficient light, without the direct sunlight striking the machine, and a fair supply of moisture. A cellar usually supplies the even temperature and moisture necessary, but is often difficult to ventilate properly. Ventilation is an important point, especially if several machines are used at the same time, as the lamps use up a large amount of oxygen, and unless this is provided for the hatches are not apt to be satis-

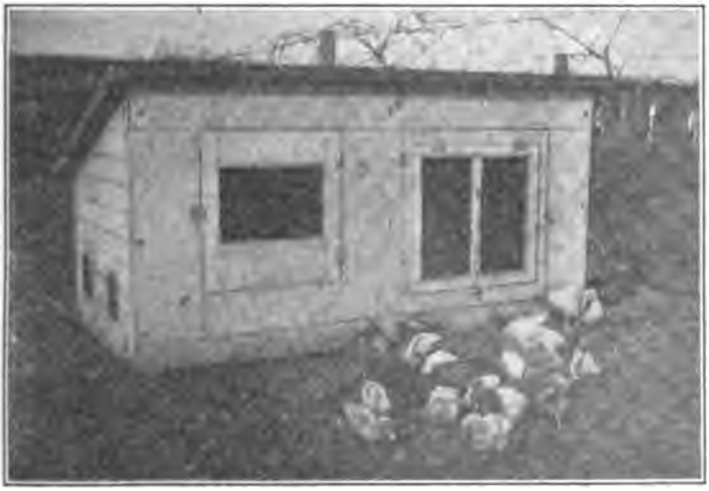


FIG. 24. A good style of outdoor brooder, giving plenty of room and light.

factory, either from the standpoint of the number of chicks hatched or the vitality of the chicks. A room partly under and partly above ground gives perhaps the best all round conditions, as here we get the advantage of the cellar in the matter of a constant temperature and a good supply of moisture, and the ventilation is much easier provided. Our incubator room is built in this way and is ventilated entirely from the windows, a cotton screen being fastened just outside the top half of the window and the windows lowered more or less, as weather conditions make necessary. The cotton screen allows the air to pass freely into the room without making a draft that would chill a machine or interfere with the lamps.

After setting up the incubator it is better to run it for a day or two before putting in the eggs, so that you may be sure that it is all right and that the regulator is working properly. When everything is running to your satisfaction put the eggs in and follow the directions sent with the machine. Don't think that you know more about it than the manufacturer does and try to run it as you or your friend have run some other make of machine or you will be apt to make a failure of it.

No matter whether it is the hen or incubator that is hatching the chicks, keep away from it at the time that the hatch is coming off. A hen is often worried by attention at this time and trampled chicks are the result. With the machine there is often a temptation to open it to help out a chick that seems to be having a hard time in getting out of the shell, and in doing so you injure a number of chicks to help one that will never amount to anything. A chicken that can not break the shell and get free himself is not worth saving.

When the hatch is over do not be in a hurry to move the chicks. They do not need any attention or feed for forty-eight hours and are better left in the machine or under the hen for this length of time. Care should be taken to see that the chicks do not get chilled.

If they are to be raised in a brooder, this should have been prepared by littering with finely cut clover or something of this nature, and being warmed up till the thermometer records ninety degrees under the hover. The addition of the chicks will raise the temperature to about ninety-five degrees, and it should be kept at this for the first week and then gradually reduced till the chicks are feathered and can do without heat. Water and sharp sand or chick-sized grit should be put in the brooder at the time that the chicks are moved. On the second day after they are hatched they may be given two light feeds, increasing the number of feeds one a day till they are getting five a day. Give only a little at a time and give it often, increasing the number of feeds rather than the amount given at a feed. This I believe is just as important as what you feed.

There are several feeds that are good for young chicks. It is hard to say which is best or that any one is best. I believe that in most cases a variety will give the best results. Rolled oats or the old-fashioned oat meal, finely cracked corn or wheat and an occasional feed of millet seed makes a good ration for chicks. These may be fed in rotation or mixed and fed together. A mixture of one part oat meal, one part finely cracked corn, two parts cracked wheat and one part of millet seed will make a good feed. This may be supplemented by one feed a day of cornbread made of two parts of coarse corn meal and one part of wheat middlings mixed with sour milk and a little soda and salt. Bake till thoroughly dry and crumble with hard boiled egg in the proportion of four parts of the bread to one of egg. At the end of two weeks substitute a dish of beef scrap for the bread and egg, continuing the grain mixture till the chicks are old enough to eat wheat and cracked corn, when they may be fed the same as the old stock. (See remarks on dry feeding on page 21.)

A plentiful supply of pure, fresh water should be before them at all times, and if, in addition, you can give all the skim milk that they will drink the beef scrap may be omitted.

Fig. 24 shows a good style of out-door brooder. The size is three feet by six feet, divided into two compartments by a removable partition. The left-hand end contains the hover and the chicks are better confined to this end for the first few days, when they may be allowed to go into the nursery end at will, care being taken to see that they find their way back the first day or two. The door on the nursery is double, having glass and wire screening, so that the glass may be opened without the chicks being able to get out of the brooder, and in this way they can be gradually hardened to the outdoor temperature before being allowed outside.

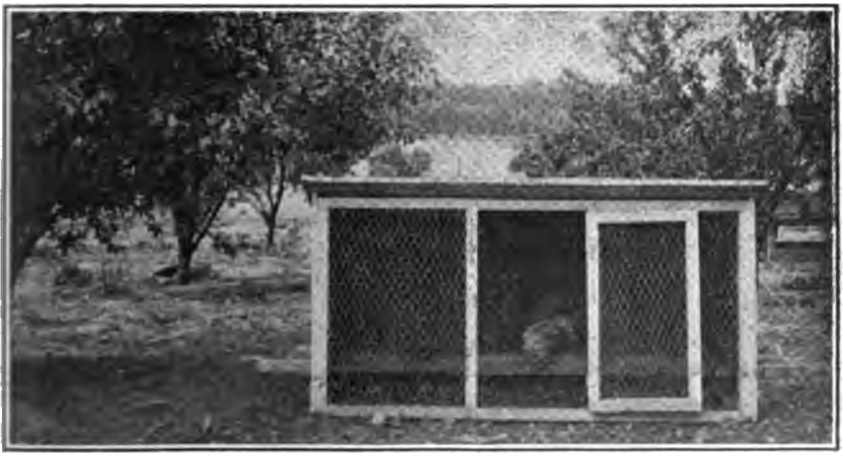


FIG. 25. A Roosting Coop. suitable for chicks from the time they are weaned till they go into winter quarters.

When the chicks are old enough to do without heat the partition and the heater may be removed, giving more room to the chicks.

When the nights become warm I prefer to substitute for the brooder the roosting coop, shown in Fig. 25, as it is more airy and still affords protection from storms, and can be closed to keep out dogs or other enemies of the chickens. This coop will be all that is necessary till the chickens are ready for winter quarters. I have wintered capons in one of these coops with good results.

HEALTH AND DISEASE.

I have tried to outline above a method of management that will reduce the loss from disease to a minimum. There is no place where the old adage, "an ounce of prevention is worth a pound of cure," is more true than in the treatment of disease in poultry. There are two reasons for this being so. In the first place the value of the individual hen is, in most cases, so small that it will cost as much or perhaps more to cure her than she is worth. Secondly, if you do cure her she should never be used in your breeding pen, as she will be very likely to transmit to her offspring the weakness that made her more subject to disease than the rest of the pen in which she was. The question, therefore, is more how to prevent disease than how to cure it.

Let me give you a few of the things that you can do to help in keeping your flock free from disease. Use for your breeding stock only birds that are strong and vigorous, fully matured and in the best possible condition. House this stock in a dry, well-ventilated, sunny house. Feed a variety of foods, including grains, animal food and green food; and lastly, but by no means least, keep the house clean and free from lice and mites.

I have mentioned before some of the indications of health and vigor in breeding stock, and also of the way to build the poultry house, and of some precautions that should be taken to help in the fight against lice and mites. I will say more here about these pests and how to get rid of them, as I am convinced that most of the troubles that we have with our fowls are due entirely to lice and filth.

Poultry parasites may be roughly divided into two classes: lice, which live on the fowls, and mites, which live in the house and attack the fowls when on the roost or in the nest.

The former are easier to fight, as they are found on the fowls, and can be killed by the use of insect powders, many of which are put up specially for use on poultry. A good powder can be made by using tobacco dust or even road dust, to which has been added a small quantity of napthalin flakes. Be careful not to use too much of the napthalin, as, while it will kill the lice, it will also injure the fowls. Young chicks are sometimes killed by being brooded by hens that have had a heavy dusting with a powder in which there is an excess of this material. Some of the special lice powders at present on the market have been causing trouble in this direction.

Mites are more dangerous, both on account of their being blood-sucking insects, and thus weakening the fowls very rapidly, and also because from their manner of living in the house and only attacking the fowls at night they are often present a long time before their presence is suspected. They are also harder to get at and kill, as they get into the cracks and crevices of the building and thus escape the means taken to destroy them.

They may be killed by thoroughly whitewashing the house with a wash to which has been added a teacupful of crude carbolic acid, creolin or a liquid lice paint to every five gallons of the wash.

Kerosene emulsion will also kill them and is cheap and easily applied with a spray pump. It is made by dissolving one pound of hard soap in one gallon of hot water and, while hot, adding two gallons of kerosene, and thoroughly stirring till cool. If you have a spray pump put the hot mixture into this, turn the nozzle into the can and pump it till cool. When wanted for use this stock may be diluted by the addition of seventeen gallons more water, making twenty gallons in all, of which two gallons, or ten per cent, is kerosene.

No matter whether you are dusting the fowls or spraying or whitewashing the house, the operation must be repeated to make a good job. In bad cases I would advise doing it three times at intervals of six days. In this way you get the second crop that have hatched from eggs that your emulsion did not reach.

To protect young chickens from the attacks of lice, especially the large head louse, grease the head and throat with lard. Try and have the hen free from lice when the chicks are hatched, and by greasing the head of each chick when it is put out with the hen and repeating the work in a week, the chick gets a good start. If you let a few of the head lice get on a young chick you may as well bury him at once, as he will, in most cases, die, and if he does not he will never amount to anything.

Serious losses with the chicks are often brought on by people continuing to raise them on the same ground year after year without taking any precautions to keep the ground from becoming poisoned.

Crop rotation is just as good practice in poultry raising as in any other branch of farming. Grow your chicks on fresh ground every year and put the last year's place in a crop to use up the droppings from the chickens. If you are obliged to use the same place year after year for the chicks see that a green crop of some kind is put in as soon as the chicks are off it, and let it grow till wanted for next year's chicks.

Bulletin No. 196 **June 1907**

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH.

SOME APPLE DISEASES

THE VOLUTELLA ROT

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.

S. L. Patterson, *ex officio* Chairman, Raleigh.

J. J. Laughinghouse	Greenville	A. T. McCallum	Red Springs.
C. W. Mitchell	Aulander.	J. P. McRae	Laurinburg.
Wm. Dunn	Newbern.	R. L. Doughton	Laurel Springs.
C. N. Allen	Auburn.	W. A. Graham	Machpelah.
R. W. Scott	Melville.	A. Cannon	Horse Shoe

STATION STAFF.

George T. Winston, L.L. D., President of the College.

B. W. Kilgore	Director.
W. A. Withers	Chemist.
Tait Butler	Veterinarian.
F. L. Stevens	Vegetable Pathologist.
J. S. Jeffrey	Poultryman.
Franklin Sherman, Jr.	Entomologist.
C. B. Williams	Agronomist.
W. N. Hutt	Horticulturist.
C. M. Conner	Agriculturist.
F. C. Reimer	Assistant Horticulturist.
Wm. Kerr	Assistant in Field Experiments.
J. C. Kendall	Assistant Dairy Husbandry.
W. A. Syme	Assistant Chemist.
J. G. Hall	Assistant Vegetable Pathologist.
W. C. Etheridge	Assistant in Field Crops
J. C Temple	Assistant Chemist and Bacteriologist
A. F. Bowen	Bursar.

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the works of the Station.

Address all communications to

AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C

PRACTICAL SUMMARY.

Several apple diseases, part of them not heretofore recognized, are described in this bulletin. They consist of two fruit rots, two twig blights and a bark disease which is called the scurf.

These diseases are all caused by fungi and are therefore probably amenable to treatment with the ordinary sprays. The existence of some of these fruit rotting fungi in winter upon twigs indicates the necessity of carefully pruning out all dead twigs to prevent infection of the fruit, and of other twigs, in following seasons.

Spraying, rendered necessary by old and too well known apple diseases, is made doubly important by the discovery of these new enemies to apple culture.

TABLE OF CONTENTS.

Page.
The Volutella Rot 41
The Coniothyrium as a Fruit Rot 49
Coniothyrium on Apple Twigs 51
Sphaeropsis on Apple Twigs 52
Apple Scurf 54

THE VOLUTELLA ROT.[1]

BY F. L. STEVENS AND J. G. HALL.

A black rot of apples, closely imitating in appearance that caused by Sphaeropsis, but differing from the Sphaeropsis rot in several details, has been observed frequently in various sections of this State, on native apples and on apples shipped into the State from a distance.

In general appearance the disease consists of a rotten black spot, frontispiece, the spot increasing in size until it eventually encompasses the whole fruit. The central and older portions of the decayed region are of an intense coal black color. The younger region of the spot, its outer border, a zone about five-eighths of an inch wide, is brownish.

Close inspection reveals the presence of slightly elevated pimple-like places in the cuticle. These are found to within about one-fourth of an inch of the edge of the spot, and become larger and more pronounced as the center of the spot is approached, indeed, the black color of the spot seems to be due to the thick setting of these black pimples all over its surface. In many instances, unless the spot be quite old, no other development is seen, and the disease might readily be considered to be the ordinary black rot, caused by Sphaeropsis, and doubtless often passes for it. In older spots, however, the pimples

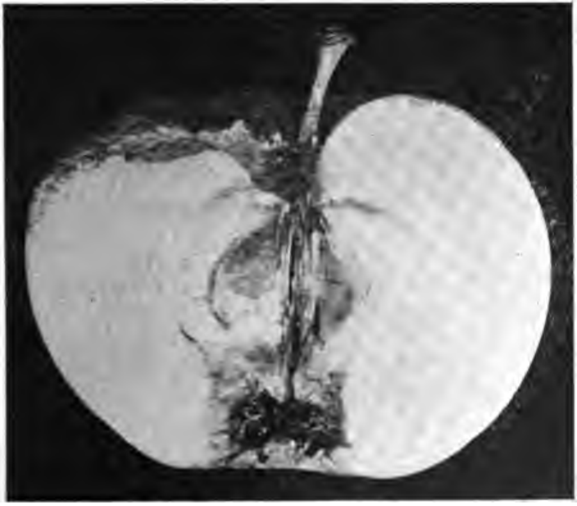


Fig. 2. The Volutella Rot in Section.

---

[1] Published in part in Journal of Mycology vol. 13, p. 94, May, 1907.

are seen to have broken through the cuticle of the apple, and each pimple appears as a small wart-like excrescence, and a good lens shows that it is thickly beset with stiff black hairs. These hairs constitute the distinctive character of this disease, and serve to separate it with ease and certainty from the Sphaeropsis rot, provided the rot is developed far enough to exhibit this character.

On slicing the apple open it is seen that the zone most recently invaded is brownish, while all of the older portion is black. (Fig. 2.)

While the decayed portions are softer than the healthy, this is in no sense a wet rot, the softness being due to a spongy dryness rather than to any watery breaking down of tissue. Upon microscopic examination the cells of the old dark, diseased portion of the apple are found to be filled with a tangled mass of black or dark brown fungous threads (Fig. 3), which are richly septate and much branched. In thickness they vary from 5 to 7 Mu[1] in the older portions. In the newly invaded cells the mycelium is usually only about 2 Mu thick and is colorless.

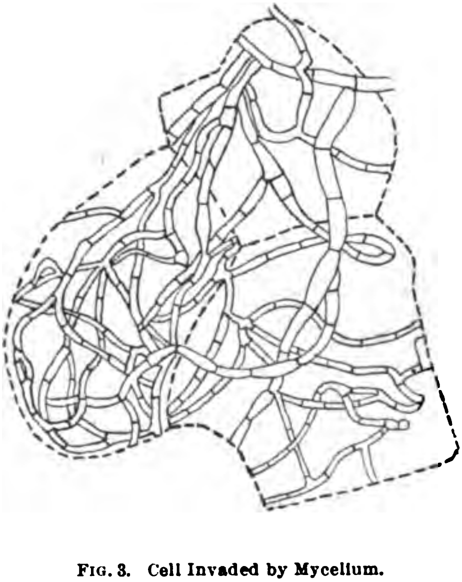


FIG. 3. Cell Invaded by Mycelium.

As the spot ages the mycelium develops more abundantly in a few layers of cells next to the cuticle, particularly immediately under the cuticle. From this sub-cuticular layer of tangled mycelium there develops a cushion of hyphae, which are arranged parallel and stand upright, perpendicular to the substratum. These hyphae are quite uniform in thickness and regular in arrangement, composed of short rectangular cells. (Fig. 4.) These upright hyphae increase in length, rupture the cuticle and develop the tubercular mass, (Fig. 5), "sporodochium," characteristic of the fungous order Tuberculariales. The tubercle attains a height of 100 to 125 Mu and a diameter nearly twice as great. About midway from base to top of the sporodochium the hyphae become narrower and the setae have their insertion (Fig. 6). The setae develop directly from hyphae which stand amid sporogenous hyphae and are indistinguishable from them, their only point of difference being that the setigerous hyphae broaden out at the end and develop into typical setae while the sporogenous proceed to spore development. Each setum is produced from the tip of a single hypha. The setae are from 100 to 400 Mu long, tapering gradually from base to tip. At base they are 5 to 8 Mu broad. They have from 2 to 5 septa (Figs. 6 and 7).

---

[1] 1 Mu equals 1-25,000 of an inch.

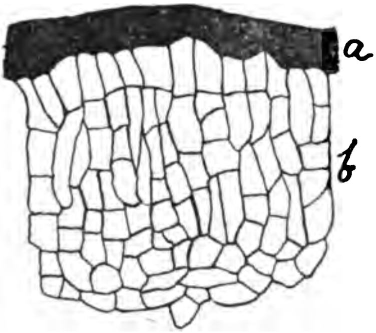


FIG. 4. Palisade Arrangement of Hyphae.

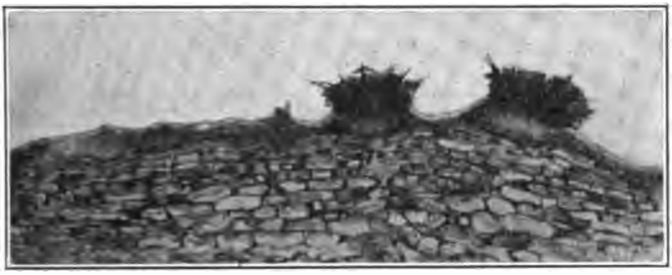


FIG 5. Sporodochia in Section.

At the upper end of the erect fuscous or black hyphae, which constitute the sporodochium, are simple, slender hyaline stalks, "conidiophores," from 25 to 35 Mu x 3 Mu long, which bear the spores (Fig. 8). The conidiophores together constitute the outermost layer of the sporodochium.

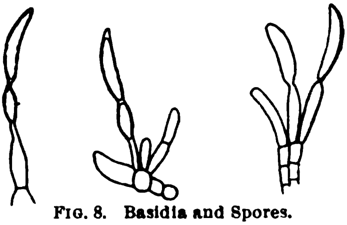


FIG. 8. Basidia and Spores.

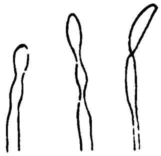


FIG. 9.
Basidia and Spores

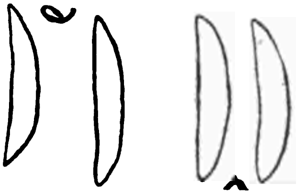


FIG. 10. Spores.

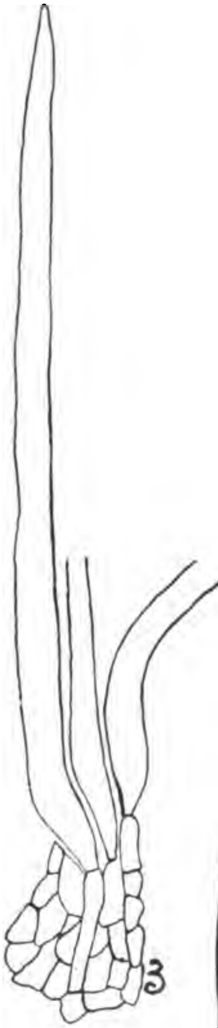


FIG. 6.
Showing Origin of Seta.

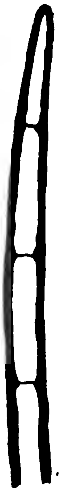


FIG. 7. Seta and Septae.

The spores are produced acrogenously, being cut off from tips of the conidiophore by a constriction of the fertile hyphae (Fig. 9).

The spores are oblong-fusoid to falcate-fusoid, with acute ends (Fig. 10), hyaline or very slightly olivaceous, continuous, though with the low power of the microscope they often appear uniseptate, due to peculiarities of the protoplasm in this region. They measure from 17 to 23 Mu long by 2.5 to 3.5 Mu broad.

Placed in apple agar in hanging drop cultures they germinate in about three hours. At first by a single hyphal thread near one end of the spore (Fig. 11), but later other points of germination can be seen. When germination begins the spores become very coarsely granular. The granules then become fewer in number and larger as germination proceeds. Later, by the migration of the granules into the young hyphae, clear spaces appear. At first there are no septae in the hyphae, but after about 25 to 30 hours a swelling is usually seen at the end of the hypha (Fig. 11), which soon becomes cut off by a wall. This cell rapidly assumes a dark color and has the appearance of the secondary spores, so characteristic a feature in the germination of the anthracnoses. As with the anthracnoses this body may remain without further development or it may germinate immediately (Fig. 12). The growth of the hypha is slow, as shown by Fig. 11. These drawings were made from the same spore, growing in a hanging drop culture, at periods of one hour.

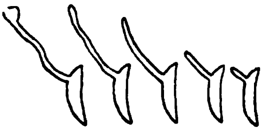


FIG. 11. Germinating Spores·

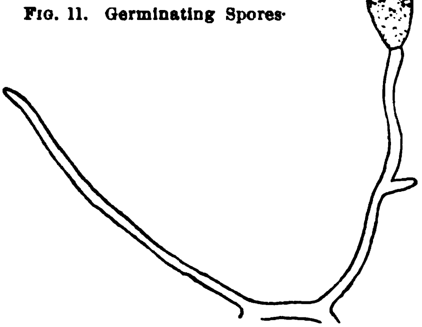


FIG. 12. Germinating Spore and Secondary Spores.

Transfers into solidified pea agar and apple agar plates were made under aseptic conditions from the regions immediately beneath the skin in a diseased spot; also from the diseased tissue near the boundary between diseased and healthy portions, and in every instance pure cultures of the fungus were obtained. By plating from water containing many of the spores pure cultures were also obtained.

When grown in media containing starch or glucose the mycelium of the fungus is densely black. In the absence of these nutrients it is colorless. In none of the artificial cultures were spores On sterilized apple twigs, however, spores were produced i ance.

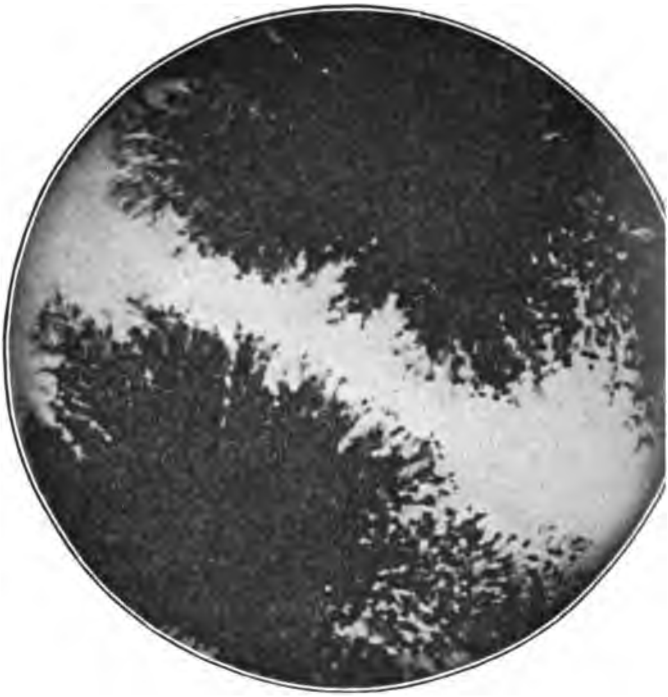


FIG. 13. Colony on Medium Rich in Carbohydrate

The effect of carbohydrate upon the color of mycelium strikingly brought out in petri dish cultures, as is shown accompanying illustration, representing colonies grown u agar and colonies grown upon apple agar. Upon apple a colonies are densely black throughout (Fig. 13). Upon p they are colorless, the only blackening being located in scatter (Fig. 14).

Inoculations were made from mycelium grown in pure cu pricking the skin of the apple and laying on, or inserting, the mycelium. Within nineteen days of the inoculation the s attained a diameter of seven-eighths of an inch. The accom illustration (Fig. 15) shows the rapidity of development in stance at room temperature, 101 hours intervening while the gressed from the inner to the outer inked circle.

Many attempts were made to secure inoculation through u cuticle, but in no instance with success. It is evident that a or break of some kind is necessary. This evidence correlat with the fact that the disease, as is true of so many fruit diseases, is much more common at the blossom end or the stem end than at other points. The rot occurs at either end of the fruit more often than elsewhere, because it is at these places that the cuticle is most liable to injury.

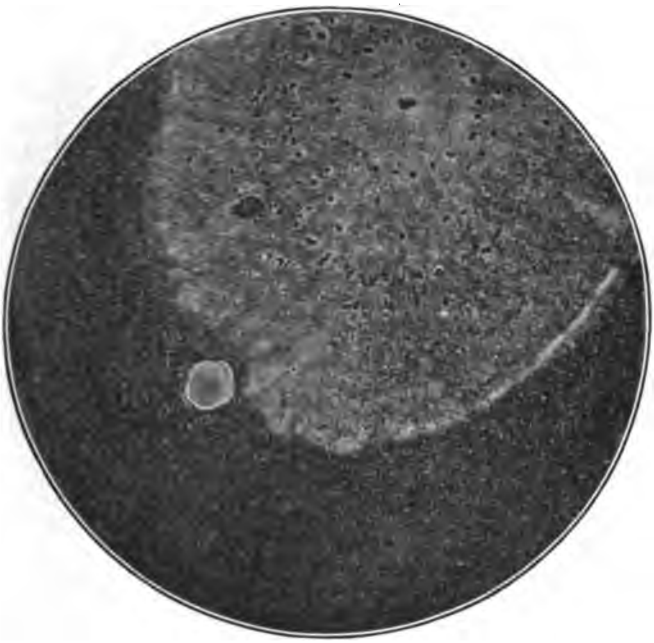


FIG. 14. Colony on Medium Poor in Carbohydrate.

The tubercular development places the fungous unquestionably among the Tuberculariales. Further, the road is not so clear. Judging strictly from the color of the mycelium it must go to the Dematiae, but a glance over its possible kin there reveals none which are of certain affinity. Admitting that it is possibly of the Mucedineae, it clearly must belong to the genus Volutella. This genus is made up mainly of light colored fungi, though several of them are very dark, notably V *Acalyphae, oxyspora, Violae, Citrulli* and *Allii.* From a structural viewpoint this fungus seems much closer to Volutella than to any of the Dematiae, and in view of the purely physiological nature of the color character, as shown by our cultures, it being dependent upon the presence of carbohydrates (which are present in abundance in the natural medium, the apple), we believe we are doing no violence to facts in placing it in the genus Volutella.

As a Volutella it stands closest to the species named above, yet is dstinct enough from them to be regarded as a separate species.

It differs from *Oxyspora* in larger sporodochia 150-400 Mu **and** longer setae, shorter spores, longer basidia; from *Cittrulli* in **shape of** spores; from *Allii,* sporodochia larger, not convex or elongate, **setae** longer; from *Violae*[1]; in character of sporodochium; from *Acalyphae* in size of spores.

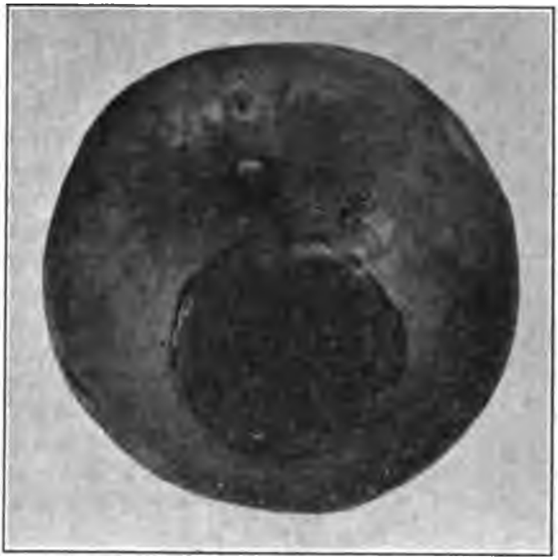


FIG. 15. Showing Rapidity of Development.

VOLUTELLA FRUCTI. STEVENS AND HALL.[2]

Sporodochia numerous in concentric circles early sub-cuticular, then erumpent, elevated from 200 to 250 Mu black. 150-400 Mu in diameter mycelium, black in presence of carbohydrates, otherwise hyaline.

Setae; distributed throughout sporodochium, black 0-3 septate, acute, smooth, 100-400 Mu long, 5 to 8 Mu thick.

Sporophores; elongate, hyaline, simple, 25-35 x 3 Mu.

Conidia; hyaline or very slightly olivaceous, continuous, smooth, oblong-fusoid to falcate-fusoid, 17-23 x 2.5-3.5 Mu.

Habitat; Fruit of *Pyrus Malorum,* North Carolina, Type N. C. Agricultural Experiment Station, No. 780.

TREATMENT.

It is probable that the sprayings usually recommended for scab and black rot will be effective in controlling the Volutella Rot.

---

[1] See Bot. Gaz., XXVI, Pl. XIV, 85.

[2] Originally described in Journal of Mycology 13, p. 94, May, 1907.

CONIOTHYRIUM AS A FRUIT ROT.

This fungus has frequently been seen causing rotten spots in apples in this State. It was first made the object of study in this laboratory in November, 1906. The rotten spot is circular in uniform tissue, brownish, about the color of the common Penicillium rot and, due to loss from evaporation, the tissue shrinks as the spot ages, leaving the surface much wrinkled (Fig. 1). Distributed somewhat sparsely and irregularly over the spot are the fruiting cavities of the fungus "pycnidia." In rotten spots produced by inoculation the pycnidia frequently assume a somewhat concentric arrangement. Proceeding from the innermost pycnidia toward the edge of the spot the pycnidia become smaller, none at all being found nearer than about 5 mm. to the edge of the diseased tissue.

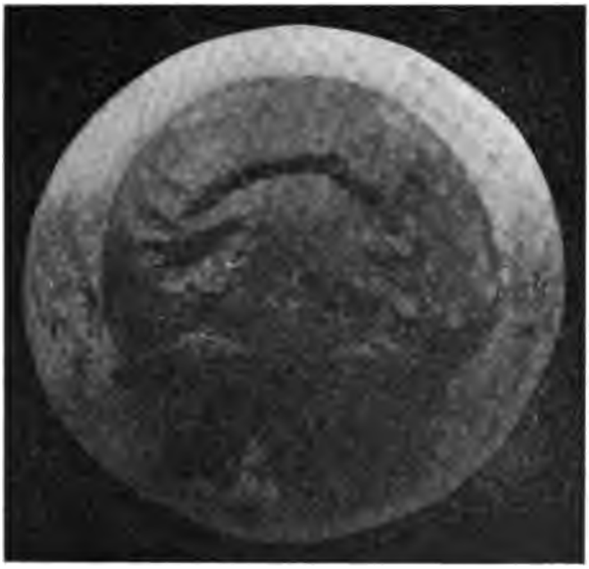


FIG. 1.—Coniothyrium Rot.

Upon sectioning through a diseased spot the flesh of the fruit is seen to be rotten, brownish and soft (Fig. 2), not black or dry, as is the case with the Volutella Rot.

Microscopic examination shows the diseased tissue to be thoroughly invaded with a thin branching septate mycelium which, when young, is hyaline, when old fuscous or straw colored.

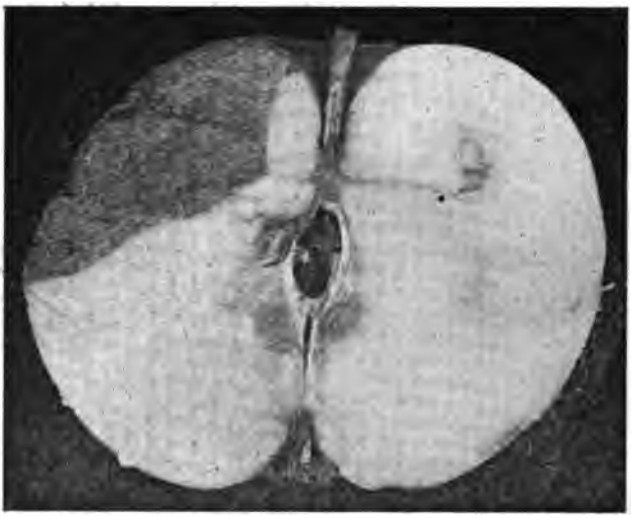


FIG. 2.—Coniothyrium Rot in Section.

The fruiting bodies lie immediately under the cuticle and consist of spherical cavities about 200 Mu in diameter, walled in by a weft of mycelial threads. When mature this pycnidium bears very numerous small black or brown spores 3-5.8 x 2-2.5 Mu (Fig. 3), approximately 250,000 spores being borne in a single pycnidium. The spores are borne on stalks standing perpendicular to the wall of the pycnidium and extending toward the central cavity.

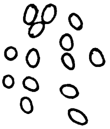


FIG. 3. Coniothyrium Spores.

As the spores accumulate pressure is exerted upon the cuticle, causing its rupture, and the spores are freed. Frequently, if the cuticle be thick, the pycnidia open under the cuticle and the spores are unable to escape until further disintegration proceeds.

The fungus is clearly a species of Coniothyrium and agrees well in all of its characters with C. *Fuckelii* Sacc. Although that species is recorded as inhabiting branches only, it is probable that it is identical with the form in question. Isolation of the fungus for the purpose of more closely studying its character was easily affected by breaking a pycnidium in sterile water and then using a cubic centimeter or so of the solution in each tube of the medium used for plating; other isolations were also made by making transfers to poured agar plates from the flesh just underneath the epidermis of the diseased spot.

In artificial culture on pea agar the fungus grows rapidly, producing a pure white mycelium. On apple agar the mycelium is tawny. Pycnidia developed upon plate cultures with extreme rarity, many cultures showing no pycnidia whatever, others a very few. In all instances where they were produced it was as the fungus became old and the agar dense or nearly dry. In some instances their arrangement upon the plate was strikingly regular and inexplicable. In one plate (Fig. 4) an almost perfect circle of pycnidia was formed at a distance of about 2.5 cm. from the point of inoculation, and though the mycelium proceeded to grow beyond this point no further pycnidia formation occurred.

FIG. 4.—Coniothyriun Showing Arrangement of Pycnidia.

Inoculated upon sterile apple twigs the mycelium was dense and white and pycnidia were produced in abundance.

CONIOTHYRIUM ON APPLE TWIGS.

Many instances of this fungus occurring upon apple twigs have come under observation during the past year. The affected twig, usually terminal portions of recent growth, dies, the bark shrinks and shrivels, turns black and at the line of demarkation between diseased and healthy tissue cracks. (Fig. 5.) The general appearance of such a twig is much like that caused by the fire blight, but is readily distinguished by the presence of very numerous, minute, pimple-like pustules, the pycnidia, distributed over the dead part.

The significance of this fungus upon twigs is twofold: 1, as a

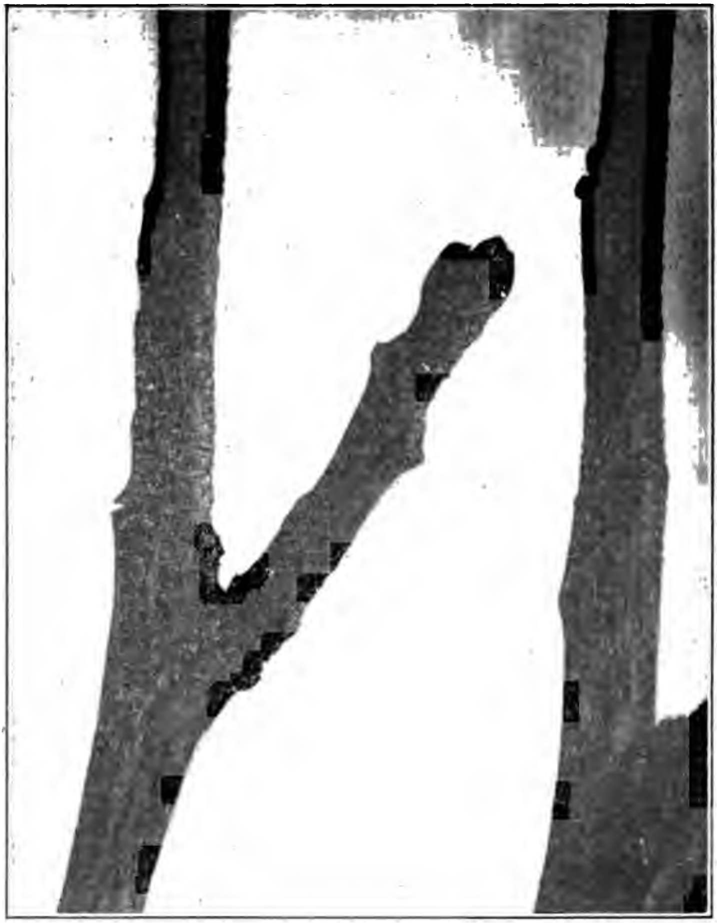


FIG. 5—Coniothyrium.

cause of the twig blight, 2, as a source of infective material, spores, to transmit the rot to the fruit.

TREATMENT.

Spraying coupled with careful pruning out and burning of diseased twigs and branches will doubtless serve as a means of control of Coniothyrium both upon branches and fruit.

SPHAEROPSIS ON APPLE TWIGS.

This fungus, long known as the cause of the black rot,[1] of the fruit and later as the cause of cankers of the limbs,[2] frequently occurs

---

[1] Peck 34th Ann'l Rept., p. 36, 1881. [2] Paddock N. Y. Exp. Station Bulletin, 163, Dec., 1899.

To determine with certainty whether this fungus was the true cause of the scurf, also whether it could gain entrance through uninjured bark, a series of inoculations was made upon the apple trees growing at the Station farm.

Some three hundred inoculations by Mr. W. F. Kirkpatrick and Mr. S. W. Foster were made by cutting from agar plates, with a sterile knife, small squares of agar bearing the fungous threads. Inoculations were made upon bruised bark and upon unbruised bark, resulting in the production of the typical diseased condition in 49.4 per cent of the inoculations upon bruised bark and only about 3 per cent of infection upon uninjured bark. While definite proof is lacking, it is probable that all infections upon unbruised bark were through lenticels.

TREATMENT.

Spraying and close pruning of affected branches will probably lead to control of this disease.

APPLE SCURF.[1]

BY F. L. STEVENS.

This is the name proposed for a disease which does not seem to have been heretofore described in the literature of apple diseases. The disease has been under observation for about two years in this Station, it having been sent to the Station with inquiries from two different sections of the State during that time.

The first specimen was received from Watauga County, N. C., in May, 1905. The chief symptom is a shrinking of the bark, including the epidermis, in such manner that minute air spaces are left immediately below the cuticle, giving to the affected region a silvery gray appearance. Close examination, especially with the aid of a lens, shows the presence of myriads of minute black pycnidia scattered throughout the affected region. Such a condition may extend over large areas on twigs one, two or three years of age. The seriousness of the disease, the amount of damage done, is unknown. That the condition has attracted the attention of practical apple growers to sufficient extent to cause them to submit specimens for diagnosis indicates that the injury is at least appreciable to the apple growers of the State. Death of the infected twigs does not always seem to follow infection. The disease is limited to the bark and would, therefore, be slow to cause death, and if it did it would be only through injury to the tree as a whole and would be gradual and insidious.

The black pycnidial bodies, referred to above, were found to contain minute spores, elliptical or oblong in shape, hyaline and about 2 x 5.8 Mu in size. The pycnidia were 100 to 125 Mu in diameter, black and provided with a minute ostiolum, from which the spores issue in coils upon being wet. The fungus clearly belongs either to the genus Phyllostica or Phoma, of which there are at least 22 species reported as growing upon the apple or its close kin. Since this species agrees closely with the description of P. *prunicola,* except in slight details, as regards the spot produced, and in the fact that P. *prunicola* is a leaf fungus, it seems best to regard it as being that species. Plate cultures in apple bark agar were made from spores in the spring of 1905, leading to a ready isolation of the fungus, which grew rapidly upon this medium.

It fruited in abundance, producing its characteristic pycnidia and spores. The colonies, owing to the color of the mycelium, were of striking brick-red color.

---

[1] Attention was called to this disease at the Spring Meeting of the North Carolina Academy of Science in May, 1905, and in the Report of the Biological Division in the Annual Report of e Station for 1904-'05, pp 20, 21.

on apple twigs as a cause of blight. Several cases came under observation in this State in 1905 and were reported in the annual report of this Station. They have also been noted by Rolfs.

In general appearance Sphaeropsis on twigs is precisely like that of Coniothyrium, as described above, with the possible difference that the pycnidia are larger and less numerous. The two can not, however, be safely distinguished without microscopic examination.

TREATMENT.

The presence of Sphaeropsis as a twig blight as well as a canker causing fungus serves, as in the case with Coniothyrium, to give this fungus wider dissemination, and indicates the necessity of most careful pruning to thereby lessen the possibility of fruit infection, as well as to prevent injury from the fungus as a twig blight.

THIRTY-FIRST ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1908

Including Scientific Papers and Bulletins Nos. 197, 198, 199

West Raleigh, North Carolina

RALEIGH:
Presses of Edwards & Broughton Printing Company
1909

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

Governor R. B. Glenn, *ex officio* Chairman, Raleigh

R. H. Ricks	Rocky Mount	J. T. Ellington	Smithfield
W. D. Turner	Statesville	W. E. Daniel	Weldon
O. M. Gardner	Shelby	W. H. Ragan	High Point
Locke Craig	Asheville	W. B. Cooper	Wilmington
C. W. Gold	Raleigh	M. B. Stickley	Concord
E. M. Koonce	Jacksonville	I. T. Ballenger	Tryon
T. W. Blount	Roper	N. B. Broughton	Raleigh
D. A. Tompkins	Charlotte	O. L. Clark	Clarkton

STATION STAFF

George T. Winston, President of the College

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
William Kerr	Assistant in Field Experiments
W. A. Syme	Assistant Chemist
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant in Farm Crops
J. C. Temple	Assistant Bacteriologist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION.

WEST RALEIGH, N. C.

EXCHANG
MICHIGAN STATE College
MAR 22 '40

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,
WEST RALEIGH, N. C., June 30, 1908.

To His Excellency, ROBERT B. GLENN,
Governor of North Carolina.

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1908.

Trusting that this report will prove satisfactory to your Excellency, I am,

Yours very truly,
C. B. WILLIAMS,
Director.

TABLE OF CONTENTS.

Page.

Board of Trustees and Experiment Station Staff 2

Letter of Submittal 4

Report of Director and Agronomist 5-12

- Report of Chemist 13-14
- Report of Biologist 15-19
- Report of Poultryman 20-21
- Report of Horticulturist 22-23
- Report of Animal Husbandman 24-25
- Report of Dairy Husbandman 26
- Report of Entomologist 27-28

Financial Statement 29

Scientific Papers—

- Experiments Upon the Effect of Formalin Upon the Germination of Oats 30-36
- A Study of Corn Mold 37-39
- Studies in Soil Bacteriology 40-63
- The Colormetric Determination of Nitrates in Soil Solutions Containing Organic Matter 64-65
- Notes on Plant Diseases Occurring in North Carolina 66-82

Bulletins—

- No. 17 (Press Bulletin)—The Grape Black Rot 83-84
- No. 197—Some Insect Enemies of Garden Crops.
- No. 198—Handling and Marketing of Milk and Cream.
- No. 199—Feeding Experiments With Cows and Calves.

THIRTY-FIRST ANNUAL REPORT

OF THE DIRECTORS OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1908

By the Director

Upon assuming the duties of Director of the Station at the beginning of the year, careful consideration with the different workers was made of plans of all experiments being conducted and of those subsequently inaugurated. In all branches of the Station new and important lines of investigation have been started, and this work in most cases is progressing in a satisfactory manner. Herewith is presented a brief statement regarding the work in progress in the several Divisions of the Station, which is made up partly from the reports of the different workers and partly from observations made by the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has been materially augmented and strengthened during the year, both by the addition of new lines of work and by the extension of experiments in progress. Much attention is being devoted to a determination of the best fertilizer combinations and the most economical quantities to use per acre; the most prolific varieties; the best methods of cultivation and handling; and the most profitable rotation for corn, cotton, wheat, oats, cowpeas and soy beans, for the conditions of climate and soil under which the experiments are being conducted. Experiments are being carried on to ascertain the best fertilizer and lime treatment for legumes. With oats, varieties are being grown both from fall and spring sowings to determine the relative value of these different sowings and the best varieties to use for seeding at the respective seasons. Much work has been put out to aid in study of the effect of proper methods of seed selection of cotton, wheat and corn upon their prolificacy and yield. This year, the variety tests will embrace a comparison of sixty-eight varieties of corn, thirty-eight of cotton, fifteen of wheat, sixty-two of oats and about fifty of cowpeas and soy beans. In addition to these, variety-distance tests are being conducted with three leading typical varieties of corn and three of cotton to determine the optimum distancing of these when grown under different conditions. In response to a popular demand for information on alfalfa and clover growing, field studies on small plats are being made to determine under what conditions of soil, fertilization and cultural management these different legumes make their best and most profitable growth. Investigations are being conducted to ascertain the factors which promote the growth of suckers on different varieties of corn, and the relation their undisturbed development sustains to total yield of grain per acre. More than fifty combinations of grasses and legumes are being experimented with to study their comparative value for hay and pasturage. A thorough system of terraces over the whole farm has been laid off and constructed at an expenditure of considerable effort and time.

DIVISION OF CHEMISTRY.

The Chemical Division has maintained a close cooperation with the Biological Division in a study of nitrogen-fixation, ammonification, nitrification and denitrification. In this cooperation the Chemist confines his attention to the chemical analyses, while the Bacteriologist looks after the bacteriological examinations. Efforts are being made to determine the nature, distribution and conditions most and least favorable for the growing of nitrogen-fixing, nitrifying, ammonifying and denitrifying bacteria. In these investigations, an especial effort is made by the Bacteriologist to isolate and identify the bacteria concerned.

DIVISION OF BIOLOGY.

The research work of the Biological Division has progressed actively along the same general course as previously reported, but has been greatly enlarged by the extension of old lines and the addition of new ones. The cooperation which has been maintained by this Division with the National Bureau of Plant Industry in a Plant Disease Survey of North Carolina and in an effort to secure melons of high eating and shipping qualities that could be grown upon land affected with watermelon wilt will be continued, and experiments have been put out on a badly infected field near Auburn. Efforts are being directed largely toward the production by hybridization and selection of strains of melons that will be wilt-resistant. The results obtained along this line during the past year have been exceedingly encouraging, as the wilt-resistant melons, which now comprise practically all that are being worked with, have been found to possess decidedly higher edible and commercial values than has been secured heretofore.

The tobacco wilt experiments which have been conducted for a number of years in the old bright tobacco belt of Granville County, for the purpose of securing wilt-resistant strains of high commercial value, will be continued. Up to this time, the resistance to this disease of about seventy varieties has been determined. On the infected areas native types of tobacco are practically wiped out by the ravages of this disease. Attention is being confined this year in these experiments to a study of six highly resistant strains, the resistance of which was brought out by last year's work. These promising strains which have been developed are two from Sumatra; two from Turkish; one from Italian; and one from local bright leaf tobacco.

The study of fungi or bacteria causing new or little known apple diseases, occurring in the State, have been continued and extended. During the period covered by these investigations, two new diseases have been discovered and several new ones have been described and much information concerning their mode of life, relation of plant growth and best methods of treatment has been worked out and published. For the present in this line of work, attention is being confined largely to morphological and physiological studies of apple rot, canker, leaf-spot and two diseases that affect the twigs, with the hope of evolving practical remedial measures.

In the lettuce drop investigations, by the construction of cold frames on the Station farm, it has been possible to prosecute the work more completely under control conditions. Outdoor experiments are being carried on which are designed to determine the longevity of the vegetative and reproductive parts of the causal fungus in the soil and in the atmosphere; under what conditions the spores infect the leaves; and the resistance of the fungus to treatment by different chemicals in varying concentrations. These experiments are being supplemented by laboratory work. The soil bacteriology investigations in cooperation with the Chemical Division have been enlarged and continued. A large number of organisms have been isolated and studied with a disclosure of the extreme variety of the presence of nitrifying power in most soils worked with. Study is being made of ammonifying organisms and the comparative rate of activity of nitrogen-fixing bacteria in soils and in solutions. Efforts are being directed towards determining the relative availability and acceptability of ammoniacal nitrogen to some of our general farm crops as compared with nitrate nitrogen. During the year, new research work on the development of poisons in milk has been started for the purpose of ascertaining the conditions under which these are produced and to determine from what source bacteria producing the toxins are derived. Attention will be given to an isolation and study of the organisms responsible for the production of these toxic principles. This work, with slight modifications, will be continued. The value of the work of this Division is attested by the large correspondence it maintains with farmers and fruit growers on plant diseases.

DIVISION OF POULTRY.

Work in the main of the Poultry Division has been conducted along the general lines of testing the relative efficiency of different breeds in food utilization, as shown by egg-production and increase in weight; various methods of handling and feeding chickens; and different styles of incubators and brooders under different systems of management. In the pedigreed breeding experiments which have now been conducted for two years the results seem to indicate an increased percentage of good layers over previous years. With careful and intelligent breeding and selection along the right lines it is expected to secure strains of greater prolificacy; of higher percentage of egg hatching; and of hardier and more robust constitution. Experiments to determine the value of disinfecting incubators and adding moisture artificially have been carried on with six machines. There seems to be a material increase in the percentage of chickens hatched from fertile eggs under these two conditions combined or separately over those hatched made in dry machines, although the incubators used were of the non-moisture type. In this connection it might be mentioned that the poultryman has secured in these moisture and disinfection experiments two hatches which have proven to be decidedly the best ones that have been made during his five years connection with the Station.

Feeding experiments have just been started to test the value of cottonseed meal for poultry feeding, when fed in different quantities and in different combinations in conjunction with corn and wheat bran. A study of the effects of inbreeding in poultry is being made to determine if it can be carried on indefinitely without producing deterioration in the flock in point of prolificacy, size and vigor, if due attention is given to these characters in mating and selecting breeding stock. This work has not progressed very far, but at this time a marked improvement in the laying capacity of many individuals has been noted.

DIVISION OF HORTICULTURE.

The Horticulturist has devoted his attention largely during the past year to outlining and getting started work of an original nature with blackberries and dewberries. At present he is confining his energies chiefly to a study of the causes and best methods of treatment of that fasciculation commonly known as "double flower," to which these are subject wherever grown commercially in North Carolina. The investigations will consist largely of a study of the structure and growth of the fascicle to determine the causes for its formation, whether due to disease, insects, physiological conditions, cultural treatment, soil or weather. The growing of blackberries in this State for market purposes was started in a small way about twenty years ago in the section around Ridgeway. From this modest beginning, the growing of these and dewberries has gradually developed, until to-day the sale of these crops bring thousands of dollars into the communities where this industry is carried on and where a few years ago there were practically no horticultural interests. This industry is centered chiefly in Warren, Moore, Cumberland, Columbus and Harnett counties, and is established in many cases on soils which are now returning annually in profit per acre fifteen to twenty times the original purchase price of the land. There are thousands of acres of sandy and sandy loam soils located in the coastal plain section of the State which, as they are at present affording little or no income to their owners, may be purchased very cheaply and which might be given over to remunerative blackberry and dewberry culture. At present, one of the most serious drawbacks to the maintenance and extension of this branch of farming is the greatly decreased yield, frequently caused by "double flower" or "rosette." Especially menacing to profitable blackberry growing is the reduced production experienced by many growers. The Wilson blackberry, the only variety grown for general market purposes, because of its appearance, edibility, shipping qualities and its date of maturity, is ordinarily so badly affected with sterility in the large number of abnormally developed flower parts as to suffer usually a reduction of about seventy-five per cent in total yield. The trouble, while not nearly so serious with dewberries, can only be held in check by costly cultural methods, such as cutting off all the young canes immediately after the picking has been finished. The determining of the cause of "rosette" will have wide practical bearing on the working out of remedial measures not only for blackberry and dewberry growers in North Carolina, but for those located in other sections of the country where these are affected with this abnormality of growth.

The work which this Division is conducting on anthracnose and self-sterility in dewberries is fraught with economic features and possibilities.

DIVISION OF ANIMAL HUSBANDRY.

As this is a new Division of the Station, a considerable portion of the time of the Animal Husbandman has been taken up in planning, providing animals and new equipment and getting under way lines of experimentation. No phase of the work has been completed, but all that has been started is being prosecuted as expeditiously as is consistent with expediency. Much effort has been devoted to a study of the effects of feeding cottonseed meal and linseed meal as supplementary feeds to corn to young and thrifty pigs with a mean average of about 100 pounds live weight, during the experiments. These experiments are designed to determine the amounts of cottonseed meal, which may be safely fed in conjunction with corn to hogs; the economy of gains made; and the quality of the pork produced, in comparison with that secured with rations of corn alone and corn and linseed meal combined. With the completion of the first half of the experiment which had been running for ninety days, it was demonstrated that 0.6 pound of cottonseed meal mixed with the other portion of the ration and fermented may be fed safely during this length period in conjunction with corn in the proportion of five parts of corn to one of meal and secure a pound of gain at less than one-half the cost of those obtained by feeding corn alone under the same conditions. A combination of linseed meal with corn in the proportion of one to five produced gains at about one-half the cost of corn fed alone; in other words, this lot by eating a little more than one-third more feed made three and one-third the amount of gain in the same length of time. These experiments which have been conducted with hogs confined in pens will be duplicated, using the same feeds combined in the same way, with hogs allowed to range on different green crops, such as rape, rye, etc., alone and in combinations. Also, cottonseed meal feeding experiments have been started with the mules and horses which are being worked on the farm. During the preliminary periods, after a few days trial, they have been found to eat from one to one and one-half pounds of meal per day with relish.

DIVISION OF DAIRY HUSBANDRY.

A portion of the time of the Dairy Husbandman has been taken up in conducting feeding experiments to determine the relative value of cottonseed hulls and corn stover as roughages; and dried brewers' grains, and crushed corn in conjunction with cottonseed meal as concentrates with corn stover as the sole roughage for milk and butter production. The first part of these experiments has been finished and show that inferior corn stover, which product is usually left in the field to rot, still had a feeding value for dairy cows equal to that of cottonseed hulls. As a result of a carefully conducted experiment in calf-feeding, it has been demonstrated that a reduction of about sixty per cent in the cost of feeding young calves during the first fourteen weeks may be effected by a gradual substitution of rolled oats for whole milk after the first week when fed in conjunction with a grain ration consisting of one part each of corn meal, linseed meal and wheat bran after the fourth week. The practical bearing of these results will be appreciated when it is considered that one pound of rolled oats, costing about four and one-half cents, contains the same nutritive value as one gallon of milk, which will sell for thirty to forty cents. Some effort has been given to planning and constructing an ice-box, a milk and cream cooler and a sterilizer that would be cheap and efficient for small dairies. With each of these as devised greater efficiency has been secured at greatly reduced cost over the means and appliances ordinarily employed. The cooling investigations have brought out the fact that to a large extent the delivery of the milk may be made entirely independent of the time of milking. Milk kept cool for fifteen hours before delivery has been found to reach the consumer in better shape than milk taken from the same cows under the same conditions and put into his hands immediately upon milking without cooling. The value of these results will be appreciated by dairymen who have had to begin milking at two to three o'clock in the morning in order to have their product come upon the market in satisfactory shape, because the milk handled in the usual way will only keep in good condition for a very few hours, especially during the summer months. By cooling to 45 degrees Fahr. and keeping the milk at this temperature, delivery may be delayed for twenty-four hours under the most trying weather conditions, thereby obviating the absolute necessity for milking earlier than a convenient hour by those who are engaged in the milk-supply business.

A study has been made of the relative efficiency in maintaining low temperatures of four different types of shipping cans for cream. Unfinished cooling and sterilizing experiments are being continued in the dairy laboratory.

DIVISION OF ENTOMOLOGY.

Much of the time of the Entomological Division during the past year has been taken up in planning and starting new lines of investigations, as the new Entomologist began work on October 1 without practically any equipment or work in progress. Studies are being made largely on the life history of the harlequin bug, cabbage webworm, cabbage aphis, corn weevil, plum curculio and peach tree borer, supplemented by experiments designed to work out more successful and practical methods for their control. Early in October the Entomologist discovered on cabbage and turnips a new species of the cabbage webworm for North Carolina, it probably having been introduced into the State during the past two years.

An insect collection, representing all the injurious forms occurring in the State, with records of date and places of occurrence, is being gradually made. During the year a Bulletin treating of about forty insects has been prepared, which gives a description, life history and remedies for the control of these insects which attack the leading truck crops grown in North Carolina.

CORN SPECIAL.

The Station, in cooperation with the Norfolk and Southern Railway, operated a Corn Special train through the Eastern portion of the State. The Special started from Raleigh on March 22 and returned on April 1. While out, visits of two hours or more were made to twenty villages and towns and talks on matters pertaining to corn growing were made. The object in running this train was to try to stimulate farmers to the production of larger yields of corn per acre by impressing upon them the importance of the adoption of better methods of selecting seed, fertilizing, cultivating, harvesting, handling and combating the insect and disease enemies of this crop. The train consisted of two audience cars and an exhibition car, and the lectures were sometimes delivered in the audience cars, sometimes in school or court-houses, and sometimes in the open where buildings were not accessible sufficiently large to accommodate the crowd. The smallest attendance was forty, and the largest between four and five hundred, and an average of one hundred and forty-five. At four places evening meetings were held, and these were devoted to lectures on the applications of Science to Agriculture and on general agricultural and educational matters. The train was furnished and operated free by the Norfolk and Southern Railway.

In the exhibition car were carried two to four type-ears of fifty-odd varieties of corn which we have been testing comparatively in the State during six or eight years, and which the farmers have heard of but which most of them have never seen. In addition to these, seed of varieties of oats, wheat and cowpeas and samples of the leading types of soil found in the State were neatly arranged in museum jars to emphasize those salient points which it was especially desired to bring out and impress. On board were also specimens of the insects and diseases which are doing most damage to the crops and orchards of North Carolina, affected plants and seeds, and spraying mixtures and apparatus that should be used in combating them.

At each stop, as far as possible, the crops and orchards were examined and affected specimens were brought into the cars and discussed and remedies recommended. It is believed that in this way the farmers in the localities visited were impressed with the importance and practical value of the work of the Station.

BULLETINS.

Bulletins have been issued as follows:

No. 197.—Some Insect Enemies of Garden Crops, by R. I. Smith.

No. 198.—Handling and Marketing of Milk and Cream, by John Michels.

No. 199.—Feeding Experiments with Cows and Calves, by John Michels.

No. 17.—(Press Bulletin)—The Grape Black Rot, by F. L. Stevens.

The reports of the heads of the several Divisions and financial statement follow:

REPORT OF CHEMIST.

During the past year the Chemical Division has made analyses of four hundred and eighty-six samples, of which four hundred and fifty-five related to the work in investigation and thirty-one were miscellaneous.

The miscellaneous samples consisted of:

Soils	3
Marls	3
Fertilizing materials	9
Feeding stuffs	6
Lemon oil and extract	3
Drinking water	1
Solutions for standardization	6

These thirty-one miscellaneous samples involved ninety-five determinations, as follows:

Chlorine	1
Sulphuric acid	1
Total nitrogen	24
Free ammonia	1
Albuminoid ammonia	1
Total phosphoric acid	15
Soluble phosphoric acid	8
Insoluble phosphoric acid	10
Silver	1
Potash	8
Lime	5
Moisture	3
Total solids	1
Insoluble matter	4
Volatile matter	1
Ash	1
Alkalinity	4
Acidity	1
Citral	3

The miscellaneous work was for the Divisions of Administration, Agronomy, Botany, Dairy Husbandry and Poultry Husbandry of the Station.

The four hundred and eighty-five samples, relating to the work in nitrogen, involved nine hundred and seventy-three determinations, as follows:

Ammonia by the Kjeldahl and Nessler methods	54
Ammonia by the Kjeldahl method	6
Ammonia by sodium hydroxid	68
Ammonia by magnesia	274

Nitrites colormetrically	284
Nitrates colormetrically	4
Nitrates by the Tiemann-Schulze method	283

This work on nitrogen has occupied the greater part of the time and energies of the Chemical Division and has consisted of a study of nitrogen fixation, ammonification, nitrification and denitrification in soils and in solutions, under different conditions and with different organisms and nutrients. The details of the work will be set forth more fully in bulletin form and in the report of the Botanical Division, in cooperation with which this work is done.

Among other conclusions reached, it has been found that the organisms concerned with nitrogen metabolism do not act the same in soils and in solutions and that there is no relation between the results in these two media. This shows that the use of soils themselves for this investigation as originally planned by this Division several years ago was wise.

This Division has devised a method for getting rid of organic matter in soil extracts so that the amount of nitrates may be determined colormetrically without interference from this cause. A paper embodying the results of this work is submitted herewith for publication.

This Division is very much handicapped for lack of room, and it is to be hoped that the next General Assembly will provide a Chemical Building for the Station and College work. In the meantime more space is very desirable.

The analytical work of this Division was performed by W. A. Syme mainly, and to a small extent by A. J. Wilson, both of whom have shown commendable zeal and corresponding success in their efforts.

Very respectfully,

W. A. Withers,
Chemist.

REPORT OF BIOLOGIST.

I beg to submit a report of the work of the Division under my charge for the fiscal year now closing:

INVESTIGATIONS CONCERNING APPLE DISEASES.

Work concerning apple diseases began in 1906 under the Adams fund, has been continued throughout the year.

Apple Twig Disease, which prevails in most sections of the State, has been closely studied. The fungus which causes it has been isolated and its character studied in pure culture. It proves to be a species of *Phyllosticta* or *Phoma,* which has been very destructive to fruit in Arkansas, West Virginia, and several other States. As yet the disease seems to be limited to the twigs, and has not been noted upon fruit here.

A second apple twig disease has been found in destructive abundance in many sections of the State. It proves to be a species of *Hypochnus,* which has not been recognized heretofore except in Brazil, where it was reported by Noack in 1898.

Apple Leaf Spot, which is very destructive, especially in the mountains, has been studied, and will be the subject of further investigation.

Cankers of apple and pear branches are exceedingly abundant and destructive, and scores of specimens have been received. These cankers have been studied and it has been determined that, in most instances, they are due to *Sphæropsis.* Sphæropsis canker of the apple is an old enemy, but it seems to be especially destructive here. Sphæropsis canker of the pear has not, to my knowledge, been known before. Both of these cankers, in addition to causing injury to the twig and branch, also bring about ripe rot of the fruit.

Monilia fructigena, causing rot of the apple, has been found and studied somewhat. This is the first time, to our knowledge, that this disease, which is exceedingly destructive in Europe, and which has been reported in some other parts of the United States, has been found in North Carolina.

INVESTIGATIONS CONCERNING LETTUCE SCLEROTINOSE.

Investigations of this exceedingly serious lettuce disease, begun under the Adams fund a year ago, have been continued throughout the past year. Two large cold frames for the raising of lettuce under canvas have been constructed on the Station farm, and a small crop of fall lettuce and a large crop of spring lettuce was raised for the purpose of studying the disease. Hundreds of plants were inoculated and the progress of the disease carefully noted. The fungus was also studied in the laboratory, receiving close attention as to the manner of infection by means of spores and mycelium; as to the life history of the fungus; number of spores formed and the condition of spore formation; action of poisons upon the fungus; its growth at normal temperatures; and other points of morphological and physiological interest. Much was learned concerning the fungus and the disease. This matter will be presented for publication in bulletin form soon. The lettuce beds, now thoroughly infected with the disease, are in excellent condition to begin a study of methods of combating the disease, using to this end the knowledge which we have gained concerning it in this year's study.

OTHER PLANT DISEASES.

Cotton Anthracnose.—Many complaints have been received from various portions of the State concerning cotton anthracnose. Some attention has been given to it in the laboratory, and some tests concerning the transmission of this disease from year to year, by seed, are under way.

A New Sweet Potato Disease.—A sweet potato disease that we are calling the "soil rot," which seems not to have been described in literature before, has been repeatedly submitted to this laboratory by sweet potato growers from various sections of the State. We have found a fungus (*Fusarium*) which is constantly associated with this disease, and which seems probably to be the cause of it. Experiments are under way to determine whether this is actually so.

An Unknown Tobacco Disease was reported to us from Hillsboro. An examination of the disease was made on the ground. Numbers of plants were dead in certain regions of the field. No cause could be assigned. Material was brought to the laboratory for further study and no fungus or parasite was found associated with this disease. If this disease should prove of permanent importance, further study will be given to it.

Corn Mold.—Samples of moldy corn have been received from about fifty farmers, and in nearly every case the mold seems to be due to a species of *Diplodia.* A report of this work on corn mold will be published soon.

Bean Anthracnose.—Material for study of seed transmission of this disease, which prevails throughout the trucking section of the State, has been secured, and a study will be made of the transmission of the disease from year to year by seed, and also of the possibility of preventing such transmission.

Cucumber Mildew.—Cucumber mildew has been very destructive in several portions of the State on both cucumbers and cantaloupes. We have planted cucumbers in our lettuce beds and will conduct spraying experiments upon them this spring.

Pear Septoria.—In the neighborhood of Wilmington, pear trees suffering very seriously from some disease were found. Laboratory study showed this disease to be caused by a species of Septoria.

COLLECTION OF PLANT DISEASES AND FUNGI.

An effort has been made to enlarge the Station collection of all kinds of parasitic fungi, either on weeds, cultivated plants, or wild plants. Also to secure typical specimens of diseases of cultivated plants.

GERMINATION OF OAT SEED.

This has been a subject of rather extensive investigation. Oats were submitted to formalin at different strength, for various lengths of time, under various conditions, using different qualities and different varieties of oats. It was found that different varieties would withstand the action of formalin differently; that the seed of poor quality are killed to a much larger extent than are seed of better quality. It thus appears that the few seed lost in the formalin treatment are undesirable ones.

PLANT BREEDING FOR DISEASE RESISTANCE.

Watermelon Wilt.—The work of testing and selecting melons with the object of securing a variety resistant to the wilt, was continued this year. Ten varieties resulting from previous selections were tested on isolated plats on sick soil at Auburn. There was a very much larger percentage of resistance this year than last, more of the plats produced edible melons and there was a very much larger percentage of edible melons on the plats, than in previous years, nearly three-fourths of the melons in some plats being of high quality.

Twenty-nine selections of seed from melons of high resistance to the disease and of highly desirable quality were made for further tests next year.

Tobacco Wilt.—Several varieties of tobacco have been developed in our previous breeding work to such an extent that they will grow with high resistance upon infected soil on which none of the ordinary varieties of tobacco will grow at all. We now have five such varieties. With one only forty plants out of nine hundred and fifteen wilted; another fifteen out of three hundred and fifty-nine; another twenty-five out of three hundred and five. These strains of tobacco will be tested again this year.

STUDY OF SPORE MEASUREMENT.

A study of spore measurement has been made with the object of ascertaining the degree of variability existing among fungi when grown under different conditions with different nutriment, etc. Results of this work are about ready for publication.

SOIL BACTERIOLOGY.

Nitrification.—Work on soil bacteriology under the Adams fund has been continued. Nitrifying organisms, both the nitrate makers and the nitrite makers, have been isolated, enabling us to study them in pure culture. An improvement upon various methods of technique has been made regarding the preparation of silicate jelly. An account of this was published in the *Centralblatt fur Bakteriologie, Parasitenkunde u. Infektionskrankheiten,* Volume XXI, No. 13, 1908. Very numerous tests have been made of the nitrifying power of various soils under various conditions, and a critical study has been made of the methods of determining nitrifying power of soils, and the factors which effect the nitrifying power. The relation of temperature, aeration, degree of moisture and chemical composition of the medium to nitrification has been closely considered. Careful study has been made of the behavior of nitrifying organisms when in solution and when in soil. It has been ascertained that there is a very great difference in the behavior of these organisms in the solution and in the soil. An attempt has been made to ascertain the reason for this difference.

Ammonification.—Ammonifying organisms have been studied much as have nitrifying organisms, to ascertain what proportion of soil organisms are ammonifiers, under what conditions they ammonify most rapidly, and the behavior of these organisms in soils and in solutions.

Nitrogen Fixing Bacteria.—Some attention has been given to these organisms, particularly as to their ability to fix nitrogen in soils, as compared with their ability to fix nitrogen when in solutions.

Availability of Ammoniacal Nitrogen as Compared with that of Nitrate Nitrogen.—This fundamentally important question has been made the subject of study in pot tests and in the field. It seems very probable, from other studies, that our soils are deficient in nitrifying power. If this be so, it is very important to know whether nitrogen in the form of ammonia is fully as acceptable to the plant as nitrogen in the form of nitrate. If the nitrate be for any reason better suited to plant nutrition, it then becomes important to devise some mode of increasing the nitrifying power of our soils.

LEGUME INOCULATION EXPERIMENT.

Tests are planned and are partially under way to determine whether the root tubercle organism of burr clover is capable of producing root tubercles upon alfalfa.

PTOMAINE INVESTIGATION.

Investigations have been begun to determine under what conditions poisonous products are formed in milk, and what source of contamination is most likely to produce such poisons. The work has not yet been carried to completion.

PLANT SURVEY.

This work is carried on in cooperation with the Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants, and to secure information concerning their distribution. On pages 66-82 are given the results of this work.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, about 4,000 pieces of mail matter have been sent out from this Division.

CORN TRAIN.

One member of this Division accompanied the corn train on its ten day trip to speak on "The Prevention of Plant Diseases." Approximately 3,000 farmers were in this way reached, concerning this important subject.

COMPLETED WORK.

There is now ready for publication a Bulletin on oat smut, containing the results of some six years' work on this subject. There was published, during the past year, a Press Bulletin on the Black Rot of the Grape. A technical article on the prevention of diseases of small fruits is also practically ready for publication.

I wish to acknowledge the efficient aid of J. C. Temple, Assistant in Soil Bacteriology, and J. G. Hall, Assistant in Pathology, each of whom is an exceedingly capable and well-trained man, enthusiastic and devoted to his work.

F. L. STEVENS,
Biologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1908:

For the past two seasons we have been pedigree breeding from a large number of hens in an effort to improve the laying qualities of our flock. The work done in this direction shows us that it is necessary, if we are to get the best results, to have more information about our breeders than simply how many eggs they each lay during the year, and for this reason we have for the past year been keeping records of the number of eggs laid by each hen, the fertility of the eggs, chicks hatched and the number living until four weeks old. The system that we have adopted of keeping the pedigree of the chicks will also give us the age of each chick, and this data should in a few years afford valuable information as to the best hatching season for profitable egg-production.

Work has also been commenced during the year to determine if inbreeding can be practiced for a number of years without detriment to the health and vigor of the stock, if proper attention is given to these characters in selecting stock.

There is a belief quite prevalent, especially among farmers, that inbreeding is detrimental in poultry work, or for utility poultry at any rate, and that if the practice is of any value it is only in the breeding of exhibition poultry.

It is believed that if it is an advantage for one class of breeders it may be just as useful to the others if properly used, and that many breeders are losing a great deal on account of their prejudice against this practice.

In order to test this we are breeding two different strains of Barred Plymouth Rocks, keeping each line pure, and as a check crossing the two from time to time to see if there is any advantage in the introduction of new blood.

Realizing that cottonseed meal is one of the cheapest and best stock feeds obtainable, we have undertaken some experiments to determine if it can be as successfully used in poultry feeding as in feeding other kinds of stock, and if so, in what proportion and combinations it will give the best results.

Considerable work has been done in artificial incubation, special attention being given this season to the question of whether it is beneficial to disinfect the incubator before each hatch, also whether the addition of moisture helped the hatch, either from the standpoint of the number of chicks hatched or the vitality of the chicks.

Six incubators were used in this work, all of one size and make, and machines which are sold as non-moisture machines, that is machines that do not need any supplied moisture. Results varied considerably from one hatch to another, and it is thought best to continue this work another season, trying as far as possible to eliminate the conditions that we think were most largely responsible for the varying results from the same machines in different hatches.

It has been the almost universal custom to raise chicks that are hatched in incubators, in brooders with artificial heat, but during the past year considerable interest has been aroused in a method of raising the chicks without supplied heat, in what is known as a fireless brooder. If this system is a success it can readily be seen that it will mean quite a saving in the cost of raising chicks artificially, saving the cost of the kerosene and the time of an attendant in looking after the lamps. Information as to this system is at present time confined almost exclusively to the claims of the parties advertising the system, and it is our intention to try this system the coming season so that we can give information as to its use to parties who are interested and want information from a disinterested source.

Respectfully submitted,

J. S. Jeffrey,
Poultryman.

REPORT OF HORTICULTURIST.

Since no experimental work had been done by the Horticultural Division for a number of years previous to my appointment, the work has of necessity been largely of a formative nature. No line of work has been carried to completion. This Division is now confining itself to the following lines of investigation:

DOUBLE FLOWER OF THE BLACKBERRY AND DEWBERRY.

This trouble, generally known as "double flower" or "double blossom" among our dewberry and blackberry growers, gets its name from the fact that there is usually a doubling of the flower. The term "rosette" would be equally applicable because of the rosette-like growth produced from the buds in spring.

The Horticulturist began studying the trouble during the summer of 1907. It was found in several sections of the State, and in each section the blackberry industry has been practically wiped out.

Experiments at Cameron.—The trouble was such a serious one that the horticulturist at once began cooperative work on a small scale with three of the leading growers at Cameron, N. C. This was to determine the nature of the abnormality, to get the growers interested, and to get the work started, since it would require at least one year before the work could be undertaken at the Experiment Station. The experiment is being conducted as follows in each field:

Four typical adjacent rows were selected in each field. The entire growth, both old and new canes, of two rows, was entirely destroyed early in July immediately after the picking season. These plants must produce sufficient new cane growth during the remainder of the season for the following year. Only the old growth (fruiting canes) was cut out of the other two rows, leaving the young cane growth made during the spring to produce the next year's crop.

This was done to determine what influence the different methods of destroying the old growth will have on the "double flower," and second, whether it is necessary to go to the heavy expense of destroying all of the cane growth, and then fertilizing heavily to produce the second growth of new canes the same season. The plants have been carefully studied since the work was started and valuable data have been obtained. Photographic records are being made of the development of the normal and abnormal buds and growth. While valuable data have already been obtained, the most important data during this season will be obtained during the fall months. Furthermore, it will require further study and experimentation before conclusive statements can be made regarding the cause and best method of controlling the trouble.

Experiments at Station Farm.—Extensive experiments with "double flower" are now being conducted on the Station farm. Six plots of Wilson blackberry and six plots of Lucretia dewberry, each plot consisting of three rows, are being devoted to this work. These plots were planted during January of the present year. These particular varieties were selected because they have been the most important, commercially, in the State and are badly affected. It will require one season to get the plants well established before any real experimental work can be undertaken. Each plot will then be treated differently in the way of pruning and destroying the old and young canes to see what effect it will have on the "double flower."

Aside from this, we are testing twenty-two other varieties of blackberries and fourteen of dewberries to determine what varieties are affected.

SELF-STERILITY OF DEWBERRIES AND BLACKBERRIES.

Many of our varieties of dewberries and blackberries give unsatisfactory results when planted by themselves. This appears to be due in many cases to self-sterility.

We are now testing fifteen varieties of dewberries and twenty-three of blackberries to determine to what extent they are self-sterile; the cause of this self-sterility, and the varieties that will be the best to use for the pollination of self-sterile varieties.

Since these plants were just planted during the past winter, no data can be obtained until they come into bearing next year.

CONTROLLING ANTHRACNOSE BY CULTURAL MEANS.

The Horticulturist is now carrying on cooperative work with five of the leading dewberry growers to determine the best cultural means of controlling this disease. It is the most serious disease with which dewberry growers have to contend at the present time.

The present methods of controlling the disease are very costly. I believe that this cost can be considerably reduced by improving and modifying the present cultural methods.

These experiments are to determine how often the canes should be cut off; the best depth to cut them, and the best tools for this purpose.

The work was started last summer and accurate records have been kept of the rate and character of new growth. This year records will be kept of the amount of fruit yielded by each plot.

MISCELLANEOUS WORK.

The Division is giving considerable study to several of our leading fruits. Photographs are being made and notes taken on the various methods of propagation, planting, cultivation, and marketing of the more important fruits. The Division has made a fairly complete survey of the dewberry industry of the State, including localities, names and addresses of growers, and acreage. A similar survey of other leading fruits is now well under way.

Respectfully submitted,
F. C. REIMER,
Horticulturist.

REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the operations of this Division for the year just closed:

It will be necessary to say at the outset that the brief report following is simply a general status of the work now in progress by this Division. No line of work has been fully completed during the past year, owing to the fact that it was necessary to provide entirely new equipment on the Station farm.

The first line of work undertaken was a determination of the amount of fermented cottonseed meal which could be fed safely in conjunction with corn to young and growing hogs; to determine the economy of gain; and the quality of the product when compared with corn alone, and corn and linseed meal.

The length of the feeding period was six months. The check lot of pigs fed on corn remained in an unthrifty condition all during the experiment.' The two lots of pigs fed on corn and cottonseed meal in varying proportions made larger gains as the amount of cottonseed meal was increased. This was true, however, only during the first period of three months. The lot which made the largest gain received the most cottonseed meal, though none of the pigs were fed more than .62 pound per day. The gains made were clearly in favor of the ration composed of four parts of corn and one part of cottonseed meal. The limit of profitable feeding was three months or thereabouts. During the last three months of the feeding period the gains were materially decreased with all pigs fed cottonseed meal, which would seem to indicate that this material should not be fed longer than seventy-five to ninety days. If fed to hogs, great care should be taken to measure or weigh the amount fed each time, and discontinue feeding after the time stated. While it is possible that the feeding period could be lengthened, it would not seem to be a safe venture for the farmer to make.

A second line of work was undertaken to determine the relation between feeding hogs in dry lots and on forage crops. The ration for each lot consisted of three parts of corn and one part of fermented cottonseed meal. With three lots, this ration was fed in conjunction with green crops; with the fourth lot, the corn and cottonseed meal were fed alone in the same proportion in a dry lot. This experiment is now nearly completed, and bids fair to give valuable data in favor of the green crops, which can be produced so abundantly by North Carolina farmers. The first grazing crop furnished was fall rye, after which oats and Canada peas; oats and rape were given as a second series in the succession. For the third series of forage crops, cowpeas and corn, cowpeas and sorghum, sweet potatoes and peanuts were fed. These crops all made rapid growth and furnished feed for the greater part of the summer and fall months.

This is one line of work which the Station expects to thoroughly investigate, as swine raising is one of the paying lines of work for the farmers in this State. The pigs in this experiment are all thrifty and will be ready for market by the latter part of December, after which the results of the experiment will be reported in detail.

The third line of work undertaken was the feeding of cottonseed meal to horses and mules to determine:

1. The possibility of using such a supplementary feed with corn.
2. The economy of the ration.
3. The amounts and condition in which it could be most satisfactorily fed.
4. The effect on the condition of the animal.

The work mules of the Station are being used in this experiment, and each mule will receive one of the rations fed each of the other mules during the experiment.

The preliminary period of the experiment, lasting from April 6 to May 20, proved conclusively that the meal was relished by the mules in quantities as large as one pound, and in some cases one and one-half pounds per day. The meal was mixed with ear-corn for two mules, and with corn and cob-meal for three mules during the first part of the final feeding period. The final ration which is being fed at the present time, is composed of ear-corn and cottonseed meal, the meal fed ranging from three-fourths of one pound to two and one-fourth pounds per day.

The above experiment is to be run one year exclusive of the preliminary period. The ration will be reversed at the end of every two months to eliminate individuality. During the first part of the experiment the same amount of meal was substituted for the corn that was taken out of the ration. At present, however, one pound of cottonseed meal is being substituted for as much as two pounds of corn, to determine the efficiency of the cottonseed meal in furnishing protein, in replacing the corn and balancing the ration.

Most farmers are feeding an all-corn ration, which is very expensive and undesirable, to say the least. The purpose of this experiment has been to work out a cheaper, practical and more efficient ration.

In addition to the above work, there has been considerable improvement made at the Station farm in the way of buildings and lots. A number of farrowing pens have been built, feeding floors, pens and hog pastures.

The Station has also purchased several high grade Poland China brood sows and a pure bred boar, which are to be used for raising hogs of uniform type for future experimental work.

Considerable correspondence has been carried on, this being mostly in reference to breeds of live stock best adapted to the conditions of the State; questions in regard to breeding, feeding and management of live stock; and the laying out lots for pasture purposes.

R. S. Curtis,
Animal Husbandman.

REPORT OF DAIRY HUSBANDMAN.

The data obtained on the relationship of cold to the keeping quality of milk prove conclusively that it is feasible for dairymen to deliver their morning's milk in the afternoon and the night's milk the following morning, thus making the milking independent of delivery. Indeed they prove that sweet milk may be furnished by making only one delivery a day. The data, therefore, point the way to saving a great deal of labor as well as much unnecessary drudgery.

The feeding experiments showing that rolled oats may be gradually substituted for milk in calf rearing, are of far-reaching importance in that the reduced cost resulting from such substitution will undoubtedly be a strong factor in inducing dairymen to raise enough calves to build up and replenish their herds.

In the stover and hull experiments conducted by this Division, the fact is brought out that dairymen will save thousands of dollars annually by raising and feeding corn stover instead of buying and feeding cottonseed hulls.

In another experiment, it was demonstrated that dried brewers' grains have the same feeding value as corn meal when both are used to supplement a grain ration consisting of one-half cottonseed meal and one-quarter corn meal. Since the dried brewers' grains can usually be purchased at a much lower price than corn meal, the economy of using them is evident.

The original plans presented for the construction of cheap ice boxes and sterilizers will, if adopted generally, save thousands of dollars to our dairymen, besides resulting in more efficient cooling and sterilizing than would be possible without them.

The Division has also worked out a new method for making cottage cheese, which is especially adapted for making this cheese on a commercial scale.

Cottage cheese has been made for centuries, but this is the first time, so far as known to the writer, that any successful effort has been made tо place the making of this cheese upon a commercial and scientific basis. The method of manufacture, as well as the method of marketing, as worked out by us, insures absolute uniformity of product, and makes it possible to manufacture cottage cheese on as large scale as is done with many other kinds of cheese.

This new method opens the way for an extensive and profitable use of skim milk.

Respectfully submitted,

JOHN MICHELS,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

When I came to the Station on the first of last October, I found the Entomological Division practically without laboratory, library and office equipment. Some little time was required to get things in shape before any investigational work could be taken up. The insect collection was found to be small, poorly arranged and contained few of the more common species. My time, therefore, for the past nine months, has been devoted largely to making insect collections—both by collecting and by breeding—to attending to correspondence, and to getting under way new lines of investigation.

PUBLICATIONS.

A Bulletin, entitled "Insects Injurious to Garden Crops," which contains sixty-four pages, has been prepared. This was written with especial reference to the needs of gardeners, truckers and farmers in North Carolina.

INVESTIGATIONS.

Life history studies, and in some instances experiments with remedial measures, have been conducted with insects as follows:

Harlequin Bug (*Murgantia histrionica*).—Commencing when the bugs first appeared this spring, careful observations and notes were made to determine the following points:

(1) Egg laying record; (2) period of incubation of eggs; (3) length of life cycle; (4) number of generations; (5) parasitism of eggs and nymphs; and (6) general habits.

Various direct remedies have been tested and the kerosene emulsion treatment of fifteen per cent strength has proved quite effective against young and half-grown bugs, while it also prevents some of the eggs from hatching. The egg-laying record of the hibernating brood has been secured, one female laying one hundred and seventy-nine eggs between April 7 and June 9. Other individuals under observation laid from ninety-six to one hundred and twenty eggs during a shorter period. Many interesting and important facts about terrapin bugs have been noted, but this line of investigation is yet in progress.

Cabbage Web-worm (*Hellula undalis*).—Plans were made this spring to study the life history of this insect, which was first discovered in North Carolina by the writer during the past October. Up to June 30 no web-worms have put in their appearance, but it is expected they will be present certainly by late summer or early fall.

Cabbage Aphis (*Aphis brassicæ*).—Gratifying results have been secured from the use of a spray of common soap solution as a remedy against the cabbage aphis. During the year tests have been made both on the College and Central Hospital farms, using various soap solutions of different concentrations in comparison with ten and fifteen per cent kerosene emulsion and tobacco decoctions, with the results indicating the superiority of common soap solution, both in efficiency and economy.

Plum Curculio (*Conotrachelus nenuphar*).—This insect was made the subject of a life history study during the spring and the length of egg, larva and pupa stages were determined for North Carolina conditions. A common species of parasite (*Sigalphus curculionis*) was reared in considerable numbers from the curculio larvæ. Observations on the egg-laying and feeding habits were made and recorded. The scope of this experiment is also to be increased, and it is to be continued during the coming year.

Fumigation Against Corn Weevils.—Because of numerous complaints of poor results coming from the use of carbon bisulphid as a remedy against corn weevils, the writer has undertaken to find some other substance or substances that will be cheap and effective. A number of tests were made during February and March, but the results, while encouraging, indicate that much further work of an enlarged nature should be carried on before attempting to draw definite conclusions. Extended work is planned to be taken up in a vigorous manner during the coming year.

Respectfully submitted,

R. I. Smith,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1907-1908.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1908, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	9,000.00

CR.

	Hatch Fund.	Adams Fund.
By Salaries	$6,945.83	$6,780.00
Labor	2,624.90	508.57
Publications	938.54	....
Postage and stationery	434.98	....
Freight and express	258.59	....
Heat, light, water and power	58.79	....
Chemical supplies	36.81	406.94
Seeds, plants and sundry supplies	445.97	367.91
Fertilizers	218.10	308.77
Feeding stuffs	733.04	....
Library	109.00	143.29
Tools, implements and machinery	350.86	....
Furniture and fixtures	566.30	....
Scientific apparatus	1.23	162.05
Live stock	457.00	200.00
Traveling expenses	467.05	122.47
Contingent expenses	15.00	....
Buildings and land	338.01	....
Total	$15,000.00	$9,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1908; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $24,000, and the corresponding disbursements $24,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)
J. T. ELLINGTON,
O. L. CLARK,
T. T. BALLENGER,
R. H. RICKS,
Auditors.

(Seal.)
Attest: A. F. BOWEN, *Custodian.*

SCIENTIFIC PAPERS.

EXPERIMENTS UPON THE EFFECT OF FORMALIN UPON THE GERMINATION OF OATS.

By F. L. STEVENS.

Many different strengths of formalin are or have been at various times recommended for the prevention of oat smut; also many different modes of application and different lengths of exposure to the formalin fumes.

The two factors which must control in the selection of the strength to be employed, and the time and the mode of application, are the fatality to the smut spores and the effect upon the germination of the grain.

While the strength of one ounce to one gallon of water is employed by many with success, it occasionally results in a loss of the crop, due to its killing the seed; therefore this strength is to be regarded as within the danger limit, and is not to be recommended.

In order to ascertain whether one ounce to two gallons of water is dangerous to seed, tests were made during May, 1905, with one hundred seeds, employing three different strengths of formalin, as indicated in the following table, and with the fertilizer in one case put in the drill, in the other well mixed with the soil, and in the third using no fertilizer:

Table I.—Showing the Effect Upon Germination of Formalin Solutions of Different Concentrations.

	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.	Average.	No Formalin.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
No fertilizer	38.5	80.5	37.5	52.2	58.0
With fertilizer mixed with soil	63.	60.5	67.5	63.7	----------
With fertilizer unmixed with soil	68.5	57.5	53.5	59.8	100.0
Average	56.7	66.2	52.8	58.7	69.0

The results are so irregular and discordant that no conclusion seems justified unless it be that in such tests a much larger number of seeds should be used to give more reliable averages. The test was therefore modified and repeated on a larger scale in June, 1905. In each instance one pint of seed was treated with the formalin solution at the rate of one gallon of solution to one bushel of seed. After treatment two hundred seeds were taken for the germination test, with the following results:

TABLE II.—SHOWING EFFECT UPON GERMINATION OF FORMALIN SOLUTIONS OF DIFFERENT CONCENTRATIONS.

	One Ounce Formalin to One-half Gallon.	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cloth-covered 12 hours after treatment then planted immediately	25	95	97	93
Planted immediately after treatment	47	90	88	89
Dried 48 hours after treatment before planting	48	96	98	94
Cloth-covered 12 hours then dried with lime before planting	35	94	94	96
Average	37	96	94	93

It comes out clearly from this experiment that the strongest solution injures germination seriously, though no injury is apparent from the treatment by the other solutions under any of these conditions. There is even an indication of increased germination with the increase of the formalin, as shown by the averages, 93, 94 and 96 per cent. Whether such stimulation is a fact or whether the differences shown in the table are due to accidental variation in the seeds it is impossible to say. There is no significant difference resulting from the modes of treatment with any of the strengths unless it be with the strongest solution, which showed greatest fatality when covered 12 hours and when planted immediately. This is to be expected, since both of these modes of treatment tend to retain the formalin fumes in contact with the seed for a longer time than do the other treatments.

The solution of one ounce of formalin to one gallon of water did no appreciable injury to these seeds with any of the modes of treatment followed. In field practice, however, this solution and even weaker solutions are known under some conditions to deplete the stand. It seemed, therefore, that some other factor must at times enter into the question; that probably there is a difference between different varieties of oats or between oats of the same variety under different conditions. A more extensive experiment was therefore planned to test the following points:

Do different varieties of oats offer different degrees of resistance to formalin? What percentage of the seed is killed by formalin of the strengths usually employed? Does formalin have any stimulating effect upon germination? Are seeds of inferior quality more susceptible than those of medium or excellent quality? Does the fatality increase with the increase of the time of application? While many tests have been made bearing upon these points, they have usually been made with one or two factors only in mind, and the results are neither concordant nor conclusive.[1]

A series of crucial experiments was planned with the hope of gaining conclusive answers to these questions.[2]

In all cases 1,000 seeds of average quality were taken and treated for twelve hours. They were treated with formalin of the strength indicated, employing 1 cc. of the solution to 9.3 cc. of seeds, this being equivalent to the usual practice of using one gallon of liquid to one bushel of seed. The seed, after being thoroughly wetted by the solution, were placed in glass capsules, of suitable size, to prevent loss of formalin by evaporation. Great care was taken to have the lots exactly alike, except as regards the factor under observation. After treatment the seeds were planted in flats in clean sifted sand in rows one-half an inch apart, with the seeds evenly distributed in the rows. In this manner, it was possible to account for every seed. The final record of germination was taken two weeks after planting, since experience showed that all viable seeds germinated in that time.

All seeds designated as of average quality were gotten by discarding from a clean commercial sample of considerable size, all foreign seeds and empty chaff, but retaining all actual oat seeds, each of which, in case of any possible doubt, was inspected as to its integrity. This sample was thoroughly mixed and the 1,000 seeds for the test were taken absolutely without selection by always taking the seed lying nearest at hand, be it large or small. The strengths most used in practice, .26 per cent, .39 per cent, and .78 per cent of formalin, or as more commonly designated, one ounce to three gallons, one ounce to two gallons, and one ounce to one gallon, were employed; also a weaker solution, one ounce to four gallons (.2 per cent formalin). The first of these is mostly used, the second often, and the third rarely.

---

[1] A summary of much that has been done is presented by G. Kock Uber die Bedeutung des Formaldehyds als, Pflanzenschutzmittel U. S. V. Zeit. f. Land—Versuchswesen, Oest—. Jahr IX 1906 811.

[2] In carrying out these tests I am indebted to the efficient assistance of F. H. Brown.

INFLUENCE OF DIFFERENT STRENGTHS UPON WHITE SPRING, RED RUST PROOF, VIRGINIA WINTER GRAY, APPLER, BURT, BLACK SPRING OAT OF AVERAGE QUALITY TREATED TWELVE HOURS.

TABLE III.—TEST OF THE WHITE SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
11	Control	998	99.8	
14	One ounce to four gallons [1]	996	99.6	—.2
15	One ounce to three gallons [2]	993	99.3	—.5
13	One ounce to two gallons [3]	985	98.5	—1.3
12	One ounce to one gallon [4]	941	94.1	—5.7

[1] .2 per cent formalin, .08 per cent formaldehyde.
[2] .26 per cent formalin, .104 per cent formaldehyde.
[3] .39 per cent formalin, .156 per cent formaldehyde.
[4] .78 per cent formalin, .312 per cent formaldehyde.

TABLE IV.—TEST OF RED RUST PROOF OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
16	Control	989	98.9	
17	One ounce to four gallons	984	98.4	—.5
20	One ounce to three gallons	984	98.4	—.5
19	One ounce to two gallons	973	97.3	—1.6
18	One ounce to one gallon	925	92.5	—6.4

TABLE V.—TEST OF VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
30	Control	895	89.5	
29	One ounce to four gallons	893	89.3	—.2
28	One ounce to three gallons	855	85.5	—.4
27	One ounce to two gallons	821	82.1	—7.4
26	One ounce to one gallon	790	79.0	—10.5

TABLE VI.—TEST OF APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
10	Control	966	96.6	
8	One ounce to four gallons	977	97.7	+1.1
9	One ounce to three gallons	958	95.8	—.8
7	One ounce to two gallons	933	93.3	—3.3
6	One ounce to one gallon	912	91.2	—5.4

TABLE VII.—TEST OF BURT OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
1	Control	903	90.3	
2	One ounce to four gallons	922	92.2	+1.9
3	One ounce to three gallons	930	93.0	+2.7
4	One ounce to two gallons	901	90.1	—.2
5	One ounce to one gallon	730	73.0	—17.3

TABLE VIII.—TEST OF THE BLACK SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
25	Control	934	93.4	
24	One ounce to four gallons	959	95.9	+2.5
23	One ounce to three gallons	949	94.9	+1.5
22	One ounce to two gallons	903	90.3	—3.1
21	One ounce to one gallon	911	91.1	—2.3

It will be noted that the White Spring, Red Rust Proof and Virginia Gray oats give perfectly consistent results, showing increasing fatality with an increase in the strength of the solution employed, the loss ranging from .2 to 5.7 per cent with the White Spring oat and from .2 to 10.5 per cent with the Virginia Gray oat.

The Appler, Burt and Black Spring oats show with the weaker of the two weakest strengths slight evidences of stimulation and an increased germination over that obtained without treatment, this varying from 1.1 per cent with the Appler to 2.5 per cent with the Black Spring oat.

Increase in fatality with increase in strength is shown with the two stronger solutions in Tables VI and VII.

The Burt oat with a loss of 17.3 per cent in germinating power, being the one when the strongest solution is considered, showing greater susceptibility than any other tested.

In Table VIII the Black Spring oat presents some inconsistencies, notwithstanding the large number of seeds used and the carefulness of the test. These may be explained, however, by the very high resistance of this oat to all strengths of solutions, thus reducing the total of fatalities to such a small number as to unduly magnify error from accidents. The high resistance offered by this oat is probably attributable to its smooth, shiny, black, hard glumes of extraordinary thickness.

It may be concluded from this series that formalin of the strength of one ounce to four gallons or one ounce to three gallons of water may be used without detriment to germination of these varieties, but that greater strength will appreciably injure the germinating power of some of them, and that the stimulating effect, if any, is insignificant.

TEST OF DIFFERENT TIME OF EXPOSURE TO FOMALIN AND OF THE USE OF LIME.

TABLE IX.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Time Treated.	Number Germinated.	Per Cent Germinated.
10	Control		966	96.6
49	One ounce to one gallon	2—10[1]	955	95.5
31	One ounce to one gallon	2 hours	934	93.4
41	One ounce to one gallon	6 "	911	91.1
6	One ounce to one gallon	12 "	912	91.2
35	One ounce to one gallon	24 "	893	89.3

[1] Formalin two hours, lime ten hours.

Table IX indicates a gradual increase in fatality with increase of the time of application, and shows slightly beneficial effect from the use of lime. Comparison of Tables IX and XI brings out the fact that the one ounce to one gallon solution may be used for two hours with greater safety than the one ounce to two gallon solution for twelve hours, and that with lime the one ounce to one gallon solution for two hours is no more injurious than the one ounce to four gallons solution for twelve hours. While no experimental evidence is at hand regarding the resistance offered by the smut spores to these solutions of different strengths for different times, it is probable that owing to the minuteness of the spores the strong solutions for the short time would be more often fatal to them than would a weaker solution for a longer time. It is probable, therefore, that in practice it will be found best to increase the strength of the solution and to use lime, rather than to increase the time.

EFFECT OF QUALITY OF SEED ON RESISTANCE TO FORMALIN.

TABLE X.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
10	Control	Average	966	96.6	5.4
6	One ounce to one gallon	Average	912	91.2	
45	Control	Good	991	99.1	3.7
46	One ounce to one gallon	Good	954	95.4	
43	Control	Medium	976	97.6	4.6
47	One ounce to one gallon	Medium	920	92.0	
44	Control	Poor	937	93.7	15.7
48	One ounce to one gallon	Poor	780	78.0	

TABLE XI.—VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
30	Control	Average	895	89.5	10.5
26	One ounce to one gallon	Average	790	79.0	
36	Control	Good	924	92.4	9.8
32	One ounce to one gallon	Good	826	82.6	
37	Control	Medium	909	90.9	10.8
33	One ounce to one gallon	Medium	801	80.1	
38	Control	Poor	859	85.9	20.
34	One ounce to one gallon	Poor	659	65.9	

Seeds such as were used in the preceding tests were carefully graded into three classes, each seed being examined individually. The largest, plumpest grains were designated as "good," the next lower class as "medium," and the smaller shrunken ones as "poor." Especial care was taken that no empty glumes, but only actual seeds, be included in this last class. With the Appler oat, Table X, it is seen that in the controls the seeds germinated according to quality, 99.1, 97.6, 93.7 per cent respectively, and that when treated with formalin, one ounce to one gallon, the loss of germinating power was little with the good seeds, a trifle more with the medium seeds, but very great with the poor seeds. The average has little or no significance, since no record was kept of the percentage of seed of each quality in the average sample.

With the Virginia Gray Oat, Table XI, less concordant results were secured. The main fact, however, comes out clearly that there is much greater fatality from treatment among the poor than among the better seed.

The fact brought out in these two last tables is very significant, in that it shows that even the slight diminution in germinating power, resulting from the formalin treatment of oats, is of benefit in that it is in effect a form of seed selection resulting in a partial elimination of the poorest seed, to the betterment of the sowing. It is probably to this fact, in part at least, that we may attribute the beneficial effects of the formalin treatment, so frequently noted, even when no smut appears in control plats.

In view of these facts, it may be desirable in practice to use the strongest solution employed in these experiments, or even stronger, as a means of culling out the poor seed, to then test the germinating power in order to ascertain the loss of live seed, and to regulate accordingly the amount of seed to use per acre for sowing. Mechanical separation might, however, attain more economically the same end.

A STUDY OF CORN MOLD.

BY F. L. STEVENS AND J. G. HALL.

The disease of corn known throughout the State as "mold," "mildew," "rot," "souring," attracted particular attention in 1906, and study of the disease was begun at that time.

The disease affects the ear, manifesting itself as a whitish growth of mold over the surface of the grains, sometimes affecting the whole ear and at other times portions only of it. The amount of fungus visible upon the superficial parts of the grain is not large, but upon breaking open the ear, it is found that the spaces between the bases of the kernels are often densely packed with masses of pure white mycelium.

Externally, no signs of fruiting bodies of any kind are apparent, but close examination at the point of attachment of the grains to the cob, in many instances, reveals the presence of exceedingly minute black specks, which under the microscope prove to be the fruiting organs (pycnidia) of the fungus.

Numerous mail inquiries have been received concerning this disease, and in response to letters, a large number of specimens, representing many different sections of the State, were received and examined. While other fungi were occasionally present, in nearly every instance the symptoms given above were predominant, and the fungus with the white mycelium and the black pycnidia was the only one that was noticed in constant association with the disease.

The pycnidia, upon examination under a microscope, were seen to be filled with rather long, slender, smoky, usually two-celled, occasionally three-celled, spores. These spores were slightly thicker at one end than at the other, and were darker in color at the thicker end than at the narrow end.

This fungus was readily isolated in culture by means of agar plates, and it has been under cultivation in the laboratory for nearly two years. It grows rapidly, producing abundant loose, floccose, aerial mycelium, and a sparse sprinkling of the characteristic pycnidia with its characteristic spores.

While longer in proportion to the thickness than is usual in the genus *Diplodia,* this fungus must be regarded as a *Diplodia;* in its relationship, however, verging toward the genera *Septoria* and *Hendersonia,* particularly toward the dark spored, short-spored septoria, such as *Septoria piricola* Desm., which grows upon the pear.

Three species of *Diplodia* have been described upon *Zea;* 1. D. *Maydis* (Berk.) Sacc. Syll. Fung. III 373; 2. D. *Frumenti* E. & E. Syll. Fung. X 292; 3, D. *Macrospora* Earle Syll. Fung. XIV 939.

These were originally described as growing upon stems and probably were saprophytic.

The species which we mention above agrees well with the description of *Diplodia Macrospora* Earle, and is without question to be regarded as *Diplodia Macrospora*, although that species has not heretofore been reported as occurring upon the ears of corn.

A second species of *Diplodia* was also found in some instances on the molding ears, evidently as a cause of the mold. This species, while to the naked eye showing no difference from *Diplodia Macrospora* as to its mycelium or pycnidia, was markedly different in shape and size of its spores, which were regularly linear-oval, evenly colored throughout and much shorter than the spores of the *Diplodia Macrospora*. This latter species agrees completely with the description of the *Diplodia Maydis* and is to be regarded as that species.

The latter species has recently been the subject of investigation in Illinois,[1] and was also reported upon at the last meeting of the American Association for the Advancement of Science.[2]

It is estimated that in 1906, the year in which there was the greatest amount of dry rot, so far as any records have been made, the loss was 4.5 per cent of the entire crop in Illinois. This represents a loss of over 15,000,000 bushels, having a value of more than $5,000,000. The loss in 1907 was less than 2 per cent of the crop or about $2,000,000.

In order to glean from the farmers as many facts as possible concerning this disease, several hundred letters were sent out to leading corn growers throughout the State, asking the following questions:

1. Under what conditions of weather does it do most damage, during wet seasons or dry seasons?
2. Is it most damaging in corn standing alone on the stalk or in corn which is put up in the shock?
3. Does it appear before the corn is husked or after?
4. If it shows before husking, does it continue to develop after husking?
5. Is there any particular variety which is more susceptible than other varieties?
6. Does the time of ripening of corn affect the rotting?
7. Estimate the amount of damage as follows:

a. Dollars per acre.
b. Per cent of crop.
c. Damage in your county.

In response to these letters we select for analysis twenty-four replies, representing the twenty-three separate counties, Jackson, Mitchell, Ashe, Madison, Caswell, Halifax, Henderson, Pasquotank, Gaston, Stokes, Sampson, Burke, Forsyth, Northampton, Yancey, Davie, Wilson, Watauga, Buncombe, Macon, Chatham, Catawba and Alamance. In ten instances, these replies were accompanied by samples of diseased corn, which proved to be unquestionably the disease under consideration. While no certainty exists that the other fourteen replies relate to this disease, it is most highly probable that they do, since the disease was carefully described, since there appears to be no hesitation on the part of the farmer as to his recognition of it, and since in the ten instances where samples were submitted, no error was noticed.

---

[1] Ill. Agricultural Experiment Station Circular 117.

[2] Science N. S. XVII, No. 684, p. 212. Dry Rot of Corn and its Causes. James T. Barrett.

As to the first question: there was an unanimity of opinion that the disease was worse in wet seasons than in dry ones. In one instance, the reply was that it was that it was worse in warm, wet weather.

As to the effect of shocking: three replies stated that there was no difference whether the corn was in shock or still standing, six replied that the disease was worse in the shock, and six replied that the disease was worse when it was not in shock, so that in all probability the disease is independent of this condition.

Regarding question number three: fifteen stated that the disease appears before the corn is shucked, while only two stated that the disease comes upon the corn after shucking. One stated that it continues to develop after shucking, eighteen state that it does not.

As to specially susceptible varieties: eleven replies were to the effect that some varieties were more subject to the disease than others. Three replies stated that there was no difference in susceptibility in the varieties. Among the varieties named as being more susceptible than others were the following:

Any early varieties, Iowa Silver Mine, Boone County White, Hickory King, Any red variety, Large Cob, Dent, Strawberry Corn, Sugar Corn, Soft Varieties, Yellow, Large Cob, Large Kernel.

The amount of damage was placed at from 10 to 50 to 75 per cent of the value of the crop. Estimates as to dollars per acre and the damage per county were so unsatisfactory as to be undeserving of analysis. It is certain, however, that the disease causes, in the aggregate, a very large loss in this State. Both species of *Diplodia* causing this mold are known to live and flourish upon corn stalks, and it is not to be doubted that the fungus multiplies on old stalks, making there enormous quantities of spores, which, spread by the wind, cause disease to the following crop. It is therefore very important to plow under, so far as is possible, all old stalks, leaves and shucks, to thus diminish the amount of infected material.

I. STUDIES IN SOIL BACTERIOLOGY.[1]

NITRIFICATION IN SOILS AND IN SOLUTIONS.

By F. L. STEVENS and W. A. WITHERS
Assisted by J. C. TEMPLE and W. A. SYME.

Following the lead of Robert Koch in 1881, in the utilization of his gelatine plate method for enumeration of the bacterial flora of various soils, came a vast number of researches directed toward a determination of the numbers of bacteria in soils from various sources, depths, conditions, etc., and much valuable information was gained as to the relative numbers of organisms obtaining in soils under different conditions. But it came to be recognized after a few years that the method of enumeration of bacterial floras by plate counts falls far short of furnishing the needed data for a proper understanding of the functions of bacteria in soils.

Attention was then directed toward methods, not to determine the *number of bacteria* in soils, but to determine the abundance or efficiency of the particular kinds of organisms that are known to be either beneficial or injurious to agricultural soils. This problem was essayed in two different ways, by Remy in 1902,[2] and Hiltner and Störmer in 1903.[3]

The method of Remy consists in using as an inoculum, weighed amounts, usually one to ten grams, of the soil under investigation, and with this inoculating sterile solutions of various composition to ascertain the chemical changes effected in the solutions by the bacteria introduced with the inoculum. In this way, for example, a 1 per cent peptone solution is inoculated, and the amount of ammonia found at the end of a given number of days is taken as an indication of the ammonifying power of the soil. Similarly, solutions containing ammoniacal compounds are employed to gain an index of the nitrifying power, and Giltay's solution is used to measure the denitifying power.

The method of Hiltner and Störmer consists in using solutions similar to those employed in Remy's method, but making in each analysis a series of inoculations with the inoculum varying from 1000 milligrams to 0.001 milligram of soil. Since, in some instances, the dilution used fails to cause reaction because the quantity of inoculum is so small as to contain none of the specific organisms in question, while in other instances there is reaction, indicating the presence of the organism, some conclusions are permissible as to the number of bacteria present of the particular kind in question in the inoculum used.

---

[1] The facts set forth in this article were presented in substantially this same form at the seventh annual meeting of the North Carolina Academy of Science May 2. 1908. See Science 27 pg. 988. This article also appears in the current volume of the Centralblatt für Bakteriologie II ab.

[2] Centr. Bakt. 2 Abt. 8 (1908) pp. 657-699, 728-761.

[3] Studien uber die Bakterienflora des Ackerbodens, Berlin, (1903).

The methods of Remy and of Hiltner and Störmer and modifications of these, have been used in numerous investigations in soil bacteriology, and much knowledge has been gained as to the abilities of the bacteria of the soil to effect changes of particular kinds in the solutions employed and under the conditions of the tests.

The use of soil itself as a culture medium in which to study the activities of bacteria under conditions of bacteriological control seems to have been singularly neglected, and when employed, has been used only for special purposes, e. g., Coleman[1] and Bazarewski,[2] who employed soil in physiological studies of nitrifying organisms, and by Wimmer[3] and Hoffman.[4]

The object of soil bacteriology is to picture clearly the kinds and intensities of bacterial activity in the soil in order that the effects of cultural methods, fertilizers, crops, etc., upon the bacterial flora and its efficiency may be known, to the end that defects may be recognized and corrective measures employed.

That the methods of Remy, of Hiltner and Störmer and of their followers come much nearer to this ideal than mere colony enumeration, can not be doubted, but that either of these methods very closely approximates actual occurrences in the soil itself is questionable. Conditions of bacterial life in solution and in soil may be, indeed they certainly are, fundamentally different, and the most that can be said with assurance, when isolated species or natural or artificial composites of species, are inoculated into solutions of known composition and produce certain chemical changes, is that the organisms present bring about the changes noted under the conditions of the test, *i. e.,* dealing with solutions of the artificial nature of those that are employed.

By such tests it has been noted that certain species of bacteria and certain live soils when placed in solution bring about nitrification, ammonification, denitrification, etc., with certain degrees of intensity. It by no means follows of necessity that the same organisms when in soils cause the same chemical changes, or if so, with the same intensities.

To picture adequately the functioning of soil bacteria, methods must be used which show as nearly as possible the effects as they are actually produced by bacteria in soils. To assume that bacterial changes produced in a solution represent the changes that would be caused by the same bacteria in a soil, is to base upon the hypothesis that the action of a given species of bacteria in a solution is the same in kind, and approximately the same in degree as is the action of the same species when in a soil.

---

[1] Untersuchungen ueber Nitrifikation Cent f. Bak. 2 abt. 20, 401, (1908).

[2] Beitrage zur Kenntnis der Nitrifikation und Denitrifikation im Boden 1906. Diss. Göttingen.

[3] Zeit. f. Hyg. 48, 160 (1904).

[4] Relation of Soil Bacteria to Nitrogenous Decomposition, 23rd Rept. Wis. Agr. Exp. St. (1906) 120.

Both upon *a priori* grounds and as the result of numerous observations during the past few years, we were led to doubt the validity of this hypothesis.[1] A series of experiments was therefore instituted to test the question: Do soil bacteria act in solutions the same as they do in soils? The results of these experiments, with other experiments of collateral bearing we here present and discuss.

We may state in advance that working with pure cultures as well as with soil composites, there is a great divergence in behavior of the same organisms when in soils and in solutions as regards nitrification,[2] denitratation, and ammonification; that some species or races affect their chemical changes in each medium, some in one only, others to different degrees in different media.

BACTERIOLOGICAL METHODS.

In all instances strict bacteriological precautions were taken to avoid contamination of the test cultures. In cases of composite or crude inoculations with soil, the soil to be used was taken with aseptic precautions, and the water, media, glassware, etc., were sterile. Unless otherwise stated, the cultures were in cotton-stoppered, Erlenmeyer flasks, and were kept in a dark incubator room at a temperature varying from 30 degrees to 35 degrees. Calcium carbonate was added to all cultures. 400 grams of air-dry soil were used with water sufficient to render one-third saturated, unless otherwise stated.

Before sterilizing, the soil and nitrogenous material (except asparagin) were mixed, the water content made as desired, and the whole flasked, plugged, autoclaved for one hour at 120 degrees, and inoculated as desired. To sterilize asparagin a definite amount was weighed into a graduated flask, and enough ether added to cover the asparagin. After twenty-four hours the ether was evaporated, sterile water added, the asparagin dissolved and made up to a definite volume. The desired amount of this solution was taken with a sterile pipette.

---

[1] Since the publication of the brief abstract of this paper in Science, 27, p. 988. Fraps (Bul. 106, Tex. Agr. Exp. Sta. p. 8) has noted that nitrification does not proceed in saturated soils, and Lipman in his book "Bacteria in Relation to Country Life," p. 338, says that "With too much (moisture) nitrification was suspended." Failue to nitrify in an almost "waterlogged" sand was also noted by Hoffman (23rd Rept. Wis. Agr. Exp. Sta).

[2] Throughout this article we employ the term ***nitrification*** which has by many writers been used in many divers ways, in what seems its most logical meaning, to designate the change of ammoniacal nitrogen to nitrate nitrogen, and the term ***nitritation*** and ***nitratation*** to mean respectively change to nitrite and nitrate, as has been done by Winogradsky. The term ***denitratation*** is introduced to designate change from the nitrate to some other form containing less oxygen.

When it was desired to absorb solutions by soil, the soil to be used was dried in an air bath at 100-105 degrees, then 200 or 400 grams of this soil were flasked, plugged, sterilized, and the solution to be absorbed, previously inoculated, was poured upon it.

Three methods of inoculation have been employed: first the desired quantity of fresh soil (the inoculum) was poured into the flask on top of the soil to be inoculated and mixed by thorough shaking; second, the soil inoculum was weighed into a flask containing the nutrient solution, and this mixture poured onto the soil medium in the flask and mixed; third, a bacterial suspension was secured by adding 100 grams of soil to 200 cc. of sterile water and shaking three minutes. Inoculations were then made with the desired amount of the suspension.

Chemical Methods.

Soil Extract.—To the sample of 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that originally in the soil, to make 1200 cc. Shaking in a shaking machine was continued for four hours. After standing over night, the solution was (1) poured off if sufficiently clear, or (2) filtered through a Pasteur-Chamberland filter,[1] or (3) after an aliquot part had been taken for the ammonia determination, the remainder was treated with lime and carbon black and filtered after precipitating the lime with a current of carbon dioxide.

Ammonia.—When nitrogen was added in the form of ammonium sulphate, it was expelled by boiling with a solution of sodium hydroxide. When it was added in organic forms, it was expelled by boiling in the presence of magnesium oxide. In either case the distillate was collected in one-fifth normal hydrochloric acid and titrated with one-tenth normal ammonium hydroxide solution, using cochineal as an indicator.

When the amount of nitrogen was less than the equivalent of 0.1 cc. of one-tenth normal ammonium hydroxide solution, the ammonia was liberated and collected in the same manner, but the amount was determined by Nesslerizing.

Nitrites and Nitrates.—The clarified solution was tested with diphenylamine,[2] which is sensitive to one part of nitrogen in the form of nitrite or nitrate in twenty millions or 0.05 milligrams nitrogen in one liter. In the case of soils where the dilution of the solution was approximately twenty times, the method would show 0.1 milligram nitrogen in 100 cc. of soil solution or about 0.06 milligram in 400 grams of soil.

Nitrites.—The sulphanilic acid method of Griess[3] was used for nitrites.

---

[1] Bureau of Soils U. S. Dept. Agr. Bul. No. 31. (1906) p. 12.

[2] Treadwell's Analytical Chemistry (1906), 1, p. 341.

[3] Bul. Soc. Chim. (3) 2, (1889); Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906), p. 41.

Nitrates.—Nitrates were usually determined by the Tiemann-Schulze method,[1] deduction being made for nitrites. When the amount of nitric oxide liberated was small, a correction was made for the amount insoluble in a concentrated solution of ferrous sulphate.

When the amount of nitrogen in the form of nitrates was very small, it was estimated by the phenol-disulphonic acid method.[2]

EXPLANATION OF TABLES.

The amounts of ammonia, nitrites and nitrates are expressed in terms of the element nitrogen.

The amounts of nitrogen found at the end of the experiment in different forms of combination are expressed in terms of percentages of the nitrogen added at the beginning of the experiment and in terms of milligrams in 100 cc. of solution. In the case of soil, unless otherwise stated, the total amount of water present with 400 grams of soil was 60 cc., which was sufficient for one-third saturation. In preparing the samples for experiment, the amount of water added was sufficient, together with that originally present in the soil, to make 60 cc. approximately.

TABLE I.—SHOWING NITRIFICATION OF BOTH AMMONIUM

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1902	10-17-07	28	Live soil 1866	400			240	$(NH_4)_2SO_4$
1903	"	28	Sterile soil 1866	400			240	$(NH_4)_2SO_4$
1904	"	28	Live soil 1866	400			240	C. S. M.
1905	"	28	Sterile soil 1866	400			240	C. S. M.
1905a	"	28	Omelianski's solu	300	Soil 1866	5	127.3	$(NH_4)_2SO_4$

NITRIFICATION IN SOILS AND IN SOLUTIONS.

Experiment No. 32.—400 grams of soil, No. 1866, from the bed of the greenhouse were placed in a liter Erlenmeyer flask. Water, containing ammonium sulphate to amount of 240 milligrams of nitrogen, was added to make one-third saturation. Another flask was similarly prepared, except that the nitrogen was in the form of cottonseed meal. Check flasks similarly prepared, but sterile, were provided in each instance. The flasks were kept in the incubator room four weeks at 30-35 degrees.

---

[1] Treadwell's Anal. Chem. (1904), Vol. 2., p. 360. Zeit. f. Anal. Chem. 14 (1870) p. 401.

[2] Jour. Am. Chem. Soc. 16, (1894); 122, 193. Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906) p. 39.

At the same time Omelianski's solution,[3] containing ammonium sulphate, was inoculated with 5 grams of the same soil and maintained under the same conditions as were the soil cultures. The results appear in Table I.

It is here evident from the soil tests, both with ammonium sulphate and with cottonseed meal, that this soil is in a vigorous nitrifying condition, yet the tests by inoculation in solution give no indication of the presence of nitrate, even by diphenylamin, capable of indicating one part of nitrate in two millions. It may be added that this soil has never nitrified in solution sufficiently to give the diphenylamin reaction, though in soil tests it has repeatedly showed itself to be in reality a vigorous nitrifier.

The entire absence of ammonia in the cultures with cottonseed meal was so striking and unexpected that the samples were again analyzed on December 5, with confirmation of the fact that neither of the cottonseed meal flasks contained ammonia.

This raised the question whether the soil under study had any ammonifying power, and tests were conducted, employing both peptone and cottonseed meal separately and inoculating with soil No. 1866. Each when tested at the end of eight days gave a considerable amount of ammonia, showing the soil to be in normal ammonifying condition. The only probable explanation of the absence of ammonia in this instance is that it was consumed by the nitrite organisms as fast as it was made. It appears also that the nitrite was likewise consumed by the nitrate organisms equally fast.

SULPHATE AND COTTONSEED MEAL IN SOILS BUT NOT IN SOLUTIONS.

Sample Number.	Percentage of Initial Nitrogen.					Milligrams of Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total recovered.	Recovered as Ammonia.	Recovered as Nitrites.	Recovered as Nitrates.	Unaccounted for.	Total recovered.	Recovered as Ammonia.	Recovered as Nitrites	Recovered as Nitrates.
1902	10.00	90.00	34.00	tr.	56.00	40.0	360.0	136.0	tr.	224.0
1903	12.40	87.60	82.00	0.20	5.60	49.6	350.4	328.0	0.8	22.4
Net					50.40				0.0	201.6
1904	54.00	46.00		tr.	46.00	216.0	184.0	0.0	0.0	184.0
1905	100.00					400.0		0.0	0.0	
Net					46.00				0.0	184.0
1905a			0.00					0.0		

---

[3] Centr f. Bak. 2 Ab. 5 537-549.

TABLE II.—SHOWING NITRIFICATION OF BOTH AMMONIUM SULPHATE AND

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
1909	10-30-07	28	Live soil 1667	400			240	$(NH_4)_2SO_4$
1910	10-30-07	28	Live soil 1667	400			240	C. S. M.
1911	10-30-07	28	Live soil, plat 10	400			240	$(NH_4)_2SO_4$
1912	10-30-07	28	Live soil, plat 10	400			240	C. S. M.
1913	10-30-07	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1914	10-30-07	28	Live soil 1867	400			240	C. S. M.
1909a	10-30-07	28	Omelianski's solu.	300	Soil 1667	5	127.3	$(NH_4)_2SO_4$
1911a	10-30-07	28	Omelianski's solu.	300	Soil plat 10	5	127.3	$(NH_4)_2SO_4$
1913a	10-30-07	28	Omelianski's solu.	300	Soil 1867	5	127.3	$(NH_4)_2SO_4$

TABLE III.—SHOWING FAILURE TO NITRIFY IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2546	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2547	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2548	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2549	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2550	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2551	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2552	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$
2553	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$

Experiment No. 34.—Three samples of soils Nos. 1667, 1867 and plat 10, 400 grams each, were taken. The soils were made to one-third saturation with water carrying 240 milligrams of nitrogen, either as ammonium sulphate or as cottonseed meal. Simultaneous inoculations were made into Omelianski's ammonia solution, using 5 grams of soil as the inoculum. All were done in duplicate. The results are given in Table II.

It is noted in this instance two of the three samples failed utterly

Cottonseed Meal by Soil No. 1867 in Soil but Not in Solution.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates
1909	12.20	87.80	87.80	tr.	0.00	73.2	526.8	526.8	tr.	0.0
1910	81.50	18.50	18.50	tr.	0.00	489.0	111.0	111.0	tr.	0.0
1911	20.70	79.30	79.30	tr.	0.00	124.2	475.8	475.8	tr.	0.0
1912	82.40	17.60	17.60	tr.	0.00	494.4	105.6	105.6	tr.	0.0
1913	1.70	98.30	42.10	tr.	56.20	6.8	398.2	168.4	tr.	224.8
1914	7.30	92.30	42.10	tr.	50.20	29.2	370.8	168.4	tr.	200.8
1909a	--------	--------	0.00	tr.	0.00	--------	--------	0.0	--------	--------
1911a	--------	--------	0.00	tr.	0.00	--------	--------	0.0	--------	--------
1913a	--------	--------	0.00	tr.	0.00	--------	--------	0.0	--------	--------

Solution but Vigorous Nitrification in Soils.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates.
2546	--------	--------	66.52	0.84	8.38	--------	--------	133.0	0.7	6.8
2547	--------	--------	67.78	1.50	8.45	--------	--------	135.6	3.0	16.9
aver.	26.93	73.07	67.15	0.92	5.92	53.9	146.1	134.3	1.8	11.8
2548	--------	--------	93.78	0.00	0.00	--------	--------	39.8	0.0	0.0
2549	--------	--------	96.36	0.00	0.00	--------	--------	40.9	0.0	0.0
aver.	4.93	95.07	95.07	0.00	0.00	2.1	40.4	40.4	0.0	0.0
2550	--------	--------	53.91	0.85	33.20	--------	--------	107.8	1.6	66.4
2551	--------	--------	62.46	0.88	7.39	--------	--------	124.9	1.8	14.6
aver	21.68	78.32	58.18	0.87	20.24	42.7	157.8	116.8	1.7	41.0
2552	--------	--------	93.60	0.00	0.00	--------	--------	39.8	0.0	0.0
2553	--------	--------	94.38	0.00	0.00	--------	--------	40.1	0.0	0.0
aver.	6.12	93.98	93.98	0.00	0.00	2.6	39.9	39.9	0.0	0.0

to nitrify either in soil or in solution, but that one sample, soil No. 1867, nitrified strongly in soil, though not at all in solution. This soil itself was known to be nearly free from nitrates.

Experiment No. 108.—Two soils were inoculated in duplicate into soils, and at the same time in duplicate into Omelianski's solution. The results in Table III give another instance of failure to nitrify in solutions, though nitrification in soil was vigorous. Though no checks were run, it is known that soil No. 1931 contained practi-

Table IV.—Showing Better Nitrification in Soil

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind	Grams.	Milligrams.	Form.
2046	2-10-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH4)_2SO_4$
2047	2-10-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH4)_2SO_4$
2048	2-10-08	28	Omelianski's solu.	300	Soil 1867	10	127.3	$(NH4)_2SO_4$
2049	2-10-08	28	Wiley's solution	300	Soil 1867	10	12.73	$(NH4)_2SO_4$
2050	2-10-08	28	Extract of soil 1867	300	Soil 1867	.10	127.3	$(NH4)_2SO_4$
2054	2-10-08	28	Omelianski's solu.	300	Soil 1867	.2	127.3	$(NH4)_2SO_4$
2055	2-10-08	28	Wiley's solution	300	Soil 1867	.2	12.73	$(NH4)_2SO_4$

cally no nitrate, and that the nitrate shown in this table is the result of nitrification during the experiment.

Experiment No. 72.—Cultures were tested by using soil extract as a medium, to ascertain whether some deficiency in the chemical constitution of the solutions used, which might not exist in soil extract itself, was responsible for the failure to nitrify in solutions.

Tests were also made in Wiley's solution[1] and Omelianski's solution using 10 grams of inoculum. The results secured at the end of four weeks are given in Table IV.

The contrast is here again strong between soil cultures Nos. 2046 and 2047, which either upon a basis of percentage of nitrification or upon a basis of milligrams nitrified per cc. of solution show a much greater nitrification than cultures in Omelianski's solution, (Nos. 2048 and 2054), which practically failed to nitrify at all. While the percentage of nitrification in Nos. 2049 and 2055 in Wiley's solution is high, this is not significant, since the absolute amount of nitrates is so small as to be almost negligible. Note initial amounts of nitrogen present. A more nearly correct comparison regarding the nitrifying power of these samples is shown in the last column, indicating only slight nitrification in the liquid medium. While there was nitrification in the soil extract No. 2050, it fell far short of that occurring in the soil itself. While this experiment, taken alone, would tend to indicate that soil extract contains something favorable to nitrification which is lacking in the artificial solutions, this conclusion is not supported by other evidence. The conclusion that soil as a medium furnishes a much more sensitive means for detection of nitrification than do the usual solutions, is, however, supported by the evidence throughout.

---

[1] Wiley, Yearbook, U. S. Dept. Agr. for 1895, p. 97.

THAN IN SOIL EXTRACT OR IN THE USUAL CULTURE SOLUTIONS.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen Per 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates
2046	19.00	81.00	59.50	0.10	21.50	76.0	324.0	238.0	0.0	86.0
2047	10.00	90.00	64.40	0.00	25.60	40.0	360.0	257.6	0.0	102.4
aver.	14.50	85.50	61.95	0.05	23.55	58.0	342.0	247.8	0.0	94.2
2048	1.20	98.80	97.00	0.00	1.80	0.5	42.0	41.2	0.0	0.8
2049	12.90	87.10	42.90	0.00	44.20[2]	0.6	3.7	1.8	0.0	1.9
2050	5.70	94.30	81.20	0.10	13.10	2.4	40.1	34.5	tr.	5.6
2054	12.20	87.80	87.10	0.00	0.70	5.5	37.0	37.0	0.0	tr.
2055	9.70[1]	109.70	102.30	0.00	7.40[2]	0.4[1]	4.7	4.4	0.0	0.3

[1] Excess.
[2] This percentage has slight significance because of the small amount of initial nitrogen.

Experiment No. 72.—Duplicate cultures of this experiment were analyzed at the end of sixty-four days. During this additional time some slight nitrification had occurred in the cultures which showed no nitrification at first analysis, but the superiority of soil as a medium for nitrification is even more apparent at the second than at the first analysis. (Compare Tables IV and V, last column.)

Basing nitrification upon the amount of nitrate produced per 100 cc. of solution, it is seen that the process is sixty-eight times as rapid in the soil water *in situ* as it is in Omelianski's or Wiley's solutions, and thirty-nine times as fast as it is in an extract of the same soil.

It seems clear from this experiment that not only are results of four week tests in solutions, such as those of Wiley, Omelianski or Ashby, worthless as indicative of the nitrifying powers of soils tested by them, but that results which are negative at the end of four weeks may indicate some nitrification if the cultures be allowed to stand for a longer time.

Experiment No. 73.—To 400 grams each of live soils Nos. 1867, 1667 and 2069 were added in the usual way 240 milligrams of nitrogen as cottonseed meal.

Flasks of Omelianski's and of Wiley's solutions were also inoculated with each of these soils. Determinations were made upon all after four weeks' incubation.

The results are presented in Table VI.

In the last column of Table VI it is noted that soils Nos. 1867 and 2069 gave a large nitrification in soil, but a nearly negligible quantity in Omelianski's or Wiley's solutions, while the third soil failed to nitrify to any extent in any medium.

TABLE V.—SHOWING RESULTS OF NITRIFICATION

Sample Number.	Date of Inoculation.	Days of Incubation.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2165	2-10-08	64	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2166	2-10-08	64	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2167	2-10-08	64	Omelianski's solution.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2168	2-10-08	64	Wiley's solution	300	Soil 1867	10	12.73	$(NH_4)_2SO_4$
2169	2-10-08	64	Extracts of soil 1867.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2173	2-10-08	64	Omelianski's solution.	300	Soil 1867	.2	127.3	$(NH_4)_2SO_4$
2174	2-10-08	64	Wiley's solution	300	Soil 1867	.2	12.73	$(NH_4)_2SO_4$

TABLE VI.—SHOWING NITRIFICATION

Number Sample.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
2060	2-13-08	28	Live soil 1867	400			240	C. S. M.
2057	2-13-08	28	Sterile soil 1867	400			0.12	C. S. M.
2061	2-13-08	28	Live soil 1667	400			240	C. S. M.
2058	2-13-08	28	Sterile soil 1667	400			0.12	C. S. M.
2062	2-13-08	28	Live soil 2069	400			240	C. S. M.
2059	2-13-08	28	Sterile soil 2069	400			0.12	C. S. M.
2063	2-13-08	28	Wiley's solution	300	Soil 1867	.2	12.7	$(NH_4)_2SO_4$
2064	2-13-08	28	Wiley's solution	300	Soil 1667	.2	12.7	$(NH_4)_2SO_4$
2065	2-13-08	28	Wiley's solution	300	Soil 2069	.2	12.7	$(NH_4)_2SO_4$
2066	2-13-08	28	Omelianski's sol	300	Soil 1867	.2	127.	$(NH_4)_2SO_4$
2067	2-13-08	28	Omelianski's sol	300	Soil 1667	.2	127.	$(NH_4)_2SO_4$
2068	2-13-08	28	Omelianski's sol	300	Soil 2069	.2	127.	$(NH_4)_2SO_4$

TESTS IN SOLUTIONS AND IN SOILS AT 64 DAYS.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates.
2165	6.80[1]	106.80	30.80	0.00	76.00	27.2[2]	427.2	123.2	0.0	304.0
2166	1.20[1]	101.20	28.80	0.00	77.40	4.8[2]	404.8	95.2	0.0	309.6
aver.	4.00[1]	104.00	27.30	0.00	76.70	16.0[2]	416.0	109.2	0.0	306.8
2167	8.00[1]	108.00	92.40	0.00	10.60	1.3[2]	43.8	39.3	0.0	4.5
2168	3.40	96.60	6 60	0.00	90.00[1]	0.2	4.1	0.8	0.0	3.8
2169	4.70	95.30	77.20	0.00	18.10	2.0	40.5	32.8	0.0	7.7
2173	6.90[1]	106.90	97.70	1.80	9.20	2.8[2]	45.3	41.4	0.6	3.9
2174	1.60[1]	101.60	26.40	tr.	75.20[1]	0.1[2]	4.3	1.1	tr.	3.2

[1] Excess.

[2] These percentages have small significance because of the small amount of nitrogen.

IN SOILS, NOT IN SOLUTIONS.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates
2060	--------	--------	------------	----------	----------	155.6	244.4	14.0	0.0	230.4
2057	--------	--------	------------	----------	----------	0.4	2.4	2.4	0.0	1.6
net	39.90	60.10	2.90	0.00	57.20	158 0	242.0	11.6	0.0	228.8
2061	--------	--------	------------	----------	----------	318.0	82.0	78.4	0.0	3.6
2058	--------	--------	------------	----------	----------	1.0	1.0	0.6	0.0	0.4
net	79.75	20.25	19.45	0.00	0.80	319.0	81.0	77.8	0.0	3.2
2062	--------	--------	------------	----------	----------	260.0	140.0	33.6	6.4	106.4
2059	--------	--------	------------	----------	----------	1.3	0.7	0.3	0.0	0.4
net	65.18	34.82	8.32	1.60	24.90	260.7	139.3	33.3	6.4	99.6
2063	41.00	59.00	0.00	3.60	59.00[1]	1.8	2.5	0.0	0.2	2.5
2064	41.90	58.10	33.00	0.00	25.10[1]	1.8	2.5	1.4	0.0	1.1
2065	50.10	49.90	39.60	tr.	10.30[1]	2.2	2.1	1.7	tr.	0.4
2066	55.10	44.90	40.90	0.20	4.00	23.4	19.1	17.4	tr.	1.7
2067	61.40	38.60	37.60	tr.	1.00	26.1	16.4	16.0	tr.	0.4
2068	50.90	49.10	48.10	tr.	11.00	21.7	20.8	20.4	tr.	0.4

[1] Not significant on account of the very small amount of initial nitrogen.

[2] C. S. M.—Cottonseed Meal.

TABLE VII.—SHOWING NITRIFICATION IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2025	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	Peptone.
2026	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	C. S. M.
2027	2-10-08	14	Peptone water	200	Soil 1867	10	60	Peptone.
2028	2-10-08	14	C. S. M. water	200	Soil 1867	10	60	C. S. M.

TABLE VIII.—SHOWING INFLUENCE OF NUMBER

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1962	12-2-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
1963	12-2-08	28	Sterile soil 1867	350	Soil 1867	50	240	$(NH_4)_2SO_4$
1964	12-2-08	28	Sterile soil 1867	300	Soil 1867	100	240	$(NH_4)_2SO_4$
1965	12-2-08	28	Sterile soil 1867	200	Soil 1867	200	240	$(NH_4)_2SO_4$
1966	12-2-08	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1967	12-2-08	28	Sterile soil 1867	400			240	$(NH_4)_2SO_4$

Making proper allowance for the very small quantity of initial nitrogen in Omelianski's and Wiley's solutions, the same conclusion is reached from the percentage of nitrogen recovered as nitrates. Two of the soils could nitrify vigorously in soils but only slightly in solutions.

Experiment No. 69a.—Four cultures were made; two in soils, one with peptone and one with cottonseed meal; two in solutions, one with peptone and one with cottonseed meal. They were inoculated in parallel with the same bacterial suspensions from soil No. 1867. Analysis on the fourteenth day gave the results shown in Table VII.

While nitrification progressed to a marked extent in both soil cultures, the solutions gave no reaction with diphenylamin. Though no checks were run with this test to determine the amounts of nitrates in these soils, our constant experimentation with them and frequent analyses assure us that there was barely a trace, or no nitrate at all, present in the soil when the experiment was set up. The amount shown by the analysis is due to nitrification during the experiment.

Experiments 56 and 57.—It seemed possible that the amount of

14 Days in Soils, Not in Solutions.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2025	51.60	48.40	11.20	1.50	37.20	103.2	96.8	22.4	3.0	74.4
2026	66.30	33.70	2.80	1.50	30.90	132.6	67.4	5.6	3.0	61.8
2027	29.60	70.40	70.40	0.00	0.00	8.9	21.1	21.1	0.0	0.0
2028	61 70	38.30	38.30	0.00	0.00	18.5	11.5	11.5	0.0	0.0

of Bacteria Upon Rapidity of Nitrification.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1962	--------	--------	60 90	0.20	lost.	--------	--------	248.6	0.8	lost.
1963	29.90	71.10	58.20	0.20	17.90	115.6	284.6	212.8	0.8	71.6
1964	34.20	65.80	42.70	0.20	23.10	136.8	263.2	170.8	0.8	97.4
1965	21.40	78.60	44.10	0.20	34.50	85.6	314.4	176.4	0.8	138.0
1966	4.60[1]	104.60	12.60	0.20	91.80	17.6[1]	417.6	50.4	0.8	367.2
1967	31.20	68.80	68.60	0.20	0.00	124.8	275.2	274.4	0.8	0.0

[1] Excess.

inoculum used might be an important factor in determining the amount, or at least the rapidity, of nitrification in early stages of incubation. To throw light upon this point, parallel cultures were made by mixing the same soil, sterile and alive, in different proportions, thus varying practically only one factor, the quantity of live organisms present. Experiment 56 consisted of such a series with nitrogen supplied in the form of ammonium sulphate; experiment 57, with nitrogen in the form of cottonseed meal.

The results are given in Tables VIII and IX.

In Table VIII there is shown a remarkably regular increase in nitrification as the quantity of inoculum increases. In Table IX, where cottonseed meal was used, if the third result be disregarded, the same relation holds true. The discrepancy in the behavior of soil No. 1970 is inexplicable, but it probably does not vitiate the general conclusions supported by these two experiments, viz, that with increase in the inoculum there is nearly a corresponding increase in the total amount of nitrification at the end of four weeks.

When tests of nitrifying power are made in the soil itself, by add-

TABLE IX.—SHOWING INFLUENCE OF QUANTITY OF BACTERIA

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1968	12-5-08	28	Sterile soil 1867	390	Soil 1867	10	240	C. S. M.
1969	12-5-08	28	Sterile soil 1867	350	Soil 1867	50	240	C. S. M.
1970	12-5-08	28	Sterile soil 1867	300	Soil 1867	100	240	C. S. M.
1971	12-5-08	28	Sttrile soil 1867	200	Soil 1867	200	240	C. S. M.
1972	12-5-08	28	Live soil 1867	400			240	C. S. M.
1973	12-5-08	28	Sterile soil 1867	400			240	C. S. M.

TABLE X.—SHOWING NO NITRIFICATION IN SOLUTIONS

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1974	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	C. S. M.
1975	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	C. S. M.
1976	12-12-07	28	Live soil 1867 Water	400 200			360	C. S. M.
1977	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	$(NH_4)_2SO_4$
1978	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	$(NH_4)_2SO_4$
1979	12-12-07	28	Live soil 1867 Water	400 200			360	$(NH_4)_2SO_4$

ing the material to be nitrified directly to the soil, it is evident that there is initially a much larger number of organisms than when 200 milligrams or even 10 grams of the soil are used as an inoculum. We may regard the direct soil tests in our work as having the equivalent of an inoculum of 400 grams.

The idea that increase in the quantity of the inoculum brings increase in nitrification arouses the suspicion that perhaps the low nitrification, or entire failure to nitrify, found by the Ashby[1] method with an inoculum of only 200 milligrams of soil, may be due to the smallness of the inoculum used.

Experiment No. 58.—This experiment was set up to test this lat-

---

[1] Jour. Chem. Soc. 85, 1158.

UPON RAPIDITY OF NITRIFICATION OF COTTONSEED MEAL.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites	Nitrates.			Ammonia.	Nitrites	Nitrates
1968	76.20	23.80	17.50	tr.	6.30	304.8	95.2	70.0	tr.	25.2
1969	70.10	29.90	13.80	tr.	16.60	280.4	119.6	58.2	tr.	66.4
1970	74.50	25.50	22.40	tr.	3.10	298.0	102.0	89.6	tr.	12.4
1971	60.20	39.80	4.90	tr.	34.90	240.8	159.2	19.6	tr.	139.6
1972	53.60	47.00	0.00	tr.	47.00	212.0	188.0	0.0	tr.	188.0
1973	97.50	2.50	0.00	tr.	2.50	390.0	10.0	0.0	tr.	10.0

C. S. M.—Cottonseed Meal.

EVEN WHEN VERY LARGE INOCULUM WAS USED.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1974	70.60	29.40	29.40	0.00	0.00	97.8	40.7	40.7	0.0	0.0
1975	48.90	51.10	51.10	tr.	0.00	67.7	70.8	70.8	tr.	0.0
1976	78.30	21.70	21.70	0.00	0.00	108.4	80.1	80.1	0.0	0.0
1977	45.40	51.60	54.60	0.00	0.00	62.9	75.6	75.6	0.0	0.0
1978	lost	lost	lost	lost	0.00	lost	lost	lost	lost	0.0
1979	43 20	56.80	56.70	tr.	0.00	60.0	78.5	78.5	tr.	0.0

C. S. M.—Cottonseed Meal.

ter point: to determine whether the failure to nitrify in solutions can fairly be attributed to the smallness of the inoculum used.

A series of tests was made in solutions, varying the amount of inoculum. In order to maintain conditions as nearly parallel as possible, the quantity of soil used in each case was the same, larger or smaller amounts of it being sterilized to give the desired variations in the number of live organisms present.

Thus in soil No. 1974, 399.5 grams of sterile soil+0.5 gram of the same live soil were used, while in No. 1979, 0 grams of sterile soil+400 grams of live soil were used. The other numbers gave intermediate conditions. Solution sufficient to cover the soil to a depth of 2.5 cm. was employed in each case, the solution also carried nitrogen

TABLE XI.—SHOWING FAILURE TO

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2621	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2622	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2623	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2621	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2627	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2628	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2629	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2630	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2631	9-10-08	28	Sterile soil 1931 Water to ⅓ satutat'n	400 60	Suspension of Soil number 1867	10
2632	9-10-08	28	Sterile soil 1931 Water to ⅓ saturat'n	400 60	Suspension of Soil number 1867	10
2635	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10
2636	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10

at the rate of 240 milligrams per 400 cc. The culture was frequently shaken, sampled, and tested by diphenylamine with negative results. At the end of four weeks, analysis was also made with still no nitrification, as is shown in Table X.

A comparison of these results with those of experiments 56 and 57, which were inoculated with the same soils, brings out again clearly the failure of the soil to nitrify at all in the solutions, although the same soil can nitrify vigorously in the same period, as is shown by actual soil tests.

Experiment No. 58 demonstrates conclusively that the differences existing between results of cultures in soils and in solutions are not to be explained by the differences in the quantities of inoculum used.

Experiment 211.—It being demonstrated that the water relation is a very important one as regards nitrification, and that nitrification proceeds not at all, or very slightly in solutions, during the time of our experiments with the soils under consideration, but vigorously in the soil itself, it became desirable to determine whether nitrification can proceed in saturated soils as well as in those of less water con-

NITRIFY IN SATURATED SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2621	--------	--------	24.51	2.25	24.29	--------	--------	98.0	9.0	97.2
2622	--------	--------	24.09	3.37	26.08	--------	--------	96.4	13.5	104.3
aver.	50.52	49.48	24.30	2.81	25.18	202.1	197.9	97.2	11.3	100.7
2623	--------	--------	50.41	0.10	0.00	--------	--------	121.0	0.3	0.0
2624	--------	--------	52.79	0.10	0.00	--------	--------	125.4	0.3	0.0
aver.	48.30	51.70	51.60	0.10	0.00	116.5	123.5	123.2	0.3	0.0
2627	--------	--------	16.80	0.25	23.82	--------	--------	40.3	0.6	57.2
2628	--------	--------	22.41	0.37	22.86	--------	--------	53.8	0.9	54.8
aver.	57.06	42.94	19.60	0.31	23.33	134.9	103.1	47.1	0.8	56.0
2629	--------	--------	63.02	0.10	0.00	--------	--------	105.0	0.2	0.0
2630	--------	--------	57.42	0.12	0.00	--------	--------	95.7	0.2	0.0
aver.	39.67	60.33	60.22	0.11	0.00	66.2	100.5	100.3	0.2	0.0
2631	--------	--------	35.01	0.23	44.79	--------	--------	140.0	0.9	179.2
2632	--------	--------	26.01	0.23	46.67	--------	--------	126.4	0.9	186.7
aver.	23.76	76.24	30.51	0.23	45.73	84.0	316.0	133.2	0.9	182.8
2635	--------	--------	43.41	0.10	tr.	--------	--------	57.9	0.1	tr.
2636	--------	--------	45.51	0.10	tr.	--------	--------	60.7	0.1	tr.
aver.	55.44	44.56	44.46	0.10	tr.	73.9	59.4	59.3	0.1	tr.

tent. To this end cultures in three different soils were prepared, some bearing water to one-third, two-thirds, and some to complete saturation. The cultures were inoculated with a suspension of soil No. 1867.

The results are given in Table XI.

It is seen that there was no trace of nitrification in the saturated soil in the case of two soils and only a trace with the other soil, though nitrification proceeded well in all soils when of two-third or one-third saturation.

In order to have a still more crucial test of nitrifying activity in soil as compared with that in solution, two portions of Omelianski's solution were prepared in the usual way, inoculated; one lot was incubated as a solution, the other portion was absorbed by sterile soil of such quantity as to render the culture about two-thirds saturated. Also an extract of soil with ammonium sulphate added to it in the usual quantity was inoculated and similarly mixed with soil. Suitable control cultures were set up. The results are given in Table XII.

TABLE XII.—SHOWING AMOUNT OF NITRIFICATION IN SOLUTION

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2034	2-3-08	28	Omelianski's sol..	240	Soil 1867......	10	101.8	$(NH_4)_2SO_4$
2035[1]	2-3-08	28	Sterile soil 1867...	400	Soil 1867......	5	50.9	$(NH_4)_2SO_4$
2036	2-3-08	28	Ext'ct of soil 1867.	240	Soil 1867......	10	101.8	$(NH_4)_2SO_4$
2038	2-3-08	28	Ext'ct of soil 1867.	240	Soil 1867......	10	101.8	$(NH_4)_2SO_4$
2037[1]	2-3-08	28	Sterile soil 1867...	400	Soil 1867......	5	50.9	$(NH_4)_2SO_4$
2039	2-3-08	28	Sterile soil 1867...	400	Soil 1867......	5	50.9	$(NH_4)_2SO_4$

TABLE XIII.—SHOWING NITRIFICATION BY

Sample Number.	Date of Inoculation.	Time of Incubation. Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2051	2-8-08	28	Sterile soil 1867...	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2052	2-8-08	28	Sterile soil 1867...	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2053	2-9-08	28	Ext'ct of soil 1867.	300	Percolator effluent	10	127.8	$(NH_4)_2SO_4$

It is seen from the first two numbers that, making proper allowances for the results of the control cultures, nitrification was vastly greater in the solution absorbed by soil than in the same solution not so absorbed, a conclusion which is clearly justified either by basing nitrification upon a per cent basis or on the amount of nitrate produced per 100 cc. of liquid in the medium.

NITRIFYING SEWER ORGANISMS.

Small quantities of nitrifying earth from the sewer beds of Lawrence, Mass., were obtained through the kindness of Dr. Stephen DeM. Gage. These samples, thrown into ammonium sulphate solution, nitrified vigorously from the start. A quantity of finely ground coke was placed in a percolator, inoculated with this nitrifying sewer-

AND IN THE SAME SOLUTION ABSORBED BY SOILS.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates.
2034	21.60	78.40	53.50	tr.	24.90	9.2	33 3	22.7	tr.	10.6
2035	14.01[2]	114.00	0.00	0.00	114.00	6.0[2]	48.5	0.0	0.0	48.5
2036	37.20	62.80	47.20	1.60	14.00	16.5	26.0	20.0	0.7	6.0
2038	95.70	4.30	0.00	0.40	3.90	40.8	1.7	0.0	0.2	1.7
net	--------	--------	------------	1.20	10.10	--------	--------	------------	0.5	4.
2037	11.60[2]	111.60	0.00	0.00	111.60	4.9	47.4	0 0	0.0	47.4
2039	58.50	41.50	19.80	0.00	21.70	24.9	17.6	8.4	0.0	9.2
net	--------	--------	------------	0.00	89.90	--------	--------	------------	0.0	38.2

[1] In 2035, 120 cc. of Omelianski's solution were inoculated with 5 g of soil 1867 and then poured over 400 g of sterile soil. In 2037, 120 cc. soil extract + ammonium sulphate were inoculated and then poured on soil in similar manner.

[2] Excess.

SEWER ORGANISMS IN SOIL AND IN SOLUTION.

	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
			Recovered as					Recovered as		
Number.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites.	Nitrates.	Unaccounted for.	Total Recovered.	Ammonia.	Nitrites	Nitrates
2051	10.60	89.40	80.50	0.00	8.90	42.4	357.6	322.0	0.0	35.6
2052	19.60	80.40	73.50	0.00	6.90	78.4	321.6	294.0	0.0	27.6
aver	15.10	84.90	------------	0.00	7.90	60.4	339.6	309.0	0.0	31.6
2053	1.80[1]	101.80	86.50	0.00	15.30	0.8[1]	43.3	36.8	0.0	6.5

[1] Excess.

bed material and ammoniacal solution poured through it once or twice daily. In this manner the coke of the percolator soon came to a still more vigorous nitrifying condition.

The effluent from this percolator formed excellent inoculating material for nitrification.

Experiment No. 72.—Inoculations were made into soil and into soil extract with the nitrifying effluent from the coke-filled percolator bearing the sewer organisms. The cultures were analyzed at the end of twenty-eight days with the results shown in Table XIII.

These cultures nitrified more vigorously in solutions than any cultures heretofore examined, and more vigorously than any of the soils among the many that we have tested during the past two years. Not only this, but basing the nitrification upon the number of grams of

TABLE XIV.—SHOWING FAILURE OF PURE

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2606	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism ite ate	1 cc.
2607	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism ite ate	1 cc.
2610	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism ite ate	1 cc.
2611	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism ite ate	1 cc.

nitrogen in the medium, it is seen that there was a larger per cent of nitrification in the solution than in the soil culture, a condition which is also without parallel in our experiments with cultures inoculated with soils.

In numerous tests, this sewer culture has proved a vigorous nitrifier in ammoniacal solutions of various compositions; it also nitrifies well in soil.

Here then is, evidently, a nitrifying organism or group of nitrifying organisms, differing radically in physiological relations from those usually found in soils here, in that it can nitrify even better in solutions than in soils.

TEST WITH PURE CULTURES.

Experiment 210.—Tests of nitrification in the presence of different amounts of water were also made, using as the inoculum 1 cc. each of cultures of pure nitrite and nitrate forming organisms[1] isolated by the Stevens-Temple silicate medium.[2]

The results of this experiment are given in Table XIV.

Here again there was large nitrification in soil cultures of one-third saturation, but no nitrification in the saturated soils.

This result is particularly significant in that it shows that the failure to find nitrates in solution and in very wet soils is in no way due to their reduction or destruction otherwise by organisms accidentally present.

---

[1] These cultures were pure in the sense that Winogradsky used the term. i. e., they would not render bouillon turbid, and they formed nitrite or nitrate respectively from appropriate lower nitrogen compounds.

[2] A convenient mode of preparing Silicate Jelly Cent. f. Bak. II ab. 21, 1908. 84.

CULTURE TO NITRIFY IN SATURATED SOILS.

Number.	Percentage of Initial Nitrogen. Unaccounted for.	Total Recovered.	Recovered as Ammonia.	Nitrite.	Nitrate.	Milligrams Nitrogen in 100 cc. Solution. Initial.	Unaccounted for.	Total Recovered.	Recovered as Ammonia.	Nitrite.	Nitrate.
2606	-------	--------	45.51	0.15	12.53	400	------	------	182.	0.6	50.1
2607	--------	--------	46.35	0.38	11.06	400	------	------	185.4	1.5	44.2
aver	42.29	57.71	45.93	0.26	11.78	400	169.1	230.9	183.7	1.	47.2
2610	-------	--------	44.11	0.07	0.00	133	------	------	58.7	tr.	0.0
2611	--------	--------	44.74	tr.	0.00	133	------	------	59.5	tr.	0.0
aver	55.53	44.47	44.47	0.04	0.00	133	73.9	59.1	59.1	tr.	0.0

BASIS FOR COMPARISON.

It is difficult to determine what is the most useful basis for comparing bacterial activity in soils with the activity of bacteria in solutions, whether to base the comparison on:

(1) The per cent of nitrogen originally present that is converted into some other form of nitrogen, or

(2) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen per cubic centimeter of soil water so converted, or

(3) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen converted per gram of moist soil.

To compare the percentages of original nitrogen converted in two different media, one weak and the other strong, as in Nos. 2049 and 2055 (see Table IV), is manifestly an unfair measure of the nitrifying power of the cultures, since a very weak nitrifier might bring about a nitrification of nearly 100 per cent in the weak medium, while a very vigorous nitrifier might nitrify to less than 40 per cent in the more concentrated medium. In such instances, a comparison of the number of milligrams of nitrogen converted per gram of medium or per cc. of liquid present, is more significant, though this comparison would also be improper, if the nitrification reached such an amount in the weaker medium as to justify the belief that cessation of nitrification was caused by lack of suitable material to work upon.

The nitrifying organisms undoubtedly live and function in the moisture in the soil, so that from the viewpoint of measuring the activity of the organisms, the second method mentioned above seems most useful. This method of comparison, however, probably tends to exaggerate the value of the changes occurring, and from a practical viewpoint, a comparison by the third method is probably the most serviceable, since it pictures approximately the relative nitrifying power of two cultures of equal weight. Each comparison has its special uses, and to enable the readers to make such comparisons as are desired, data are given to admit of the use of each of the comparisons suggested.

A comparison of nitrification in soils with nitrification in solutions is probably of very little significance except for the special purpose of this present article, unless some relation can be established showing that the vigor of nitrification in a certain solution can be taken as an index of the nitrifying vigor of the soil used to inoculate the solution.

General Considerations.

The evidence of the tables presented, together with the results of numerous other experiments during our experience of the last two years, forces the conclusion that not all soils which can bring about vigorous nitrification of ammonium sulphate and cottonseed meal in soils in four weeks can nitrify in solutions during that time. Numerous instances show that among the natural soils of this locality few or none can cause nitrification in solution in four weeks, if at all. It is established also that some of these soils which cause nitrification not at all or slightly in Omelianski's, Ashby's, Wiley's, or other ammoniacal solutions, can still nitrify vigorously as soils. It is also brought out that the failure to nitrify is not due to the fact that a small inoculum is used in solution, since in the experiments given in detail there was no nitrification even when 400 grams of the live soil were used as an inoculum, and repeated experiments have also shown that the presence of water to or above the point of saturation inhibits nitrification with the soils here used. Notwithstanding this fact, sewer-bed soil nitrified as well in solutions as it did in soils.

From these facts, it seems that no trustworthy, reliable evidence as to the actual nitrifying power of a soil can be gained by inoculating the soil into solutions in the usual way, unless in the case of soils which are naturally very wet, offering practically the conditions obtaining in a solution. If negative results are had from solution tests, it may well be, as is the case of certain soils of this locality, that a type of nitrifying organism or composite of organisms is present which is capable of nitrifying in soils, but not in solutions; and that though the result is of negative indication, the soil may in reality be a vigorous nitrifier.

If positive results are had, it may be that the soil contains an organism similar to the sewer organisms experimented with, which nitrified more vigorously in solutions than in soils, and that while the indication given by the test is of vigorous nitrifying power, the soil may in reality be of low nitrifying power.

Tests by the method of liquid cultures are not of value even for purposes of comparing the nitrifying power of two soils, since two soils may nitrify to different degrees and yet both give negative results in solutions, or one bearing a vigorous soil-nitrifier may give a negative result, and another bearing a vigorous solution-nitrifier, though weak as a soil-nitrifier, may give a strong, positive result.

It seems, then, that to gain a useful indication of the nitrifying vigor of a soil, the soil itself must be used as a medium. To picture conditions as they are in the field, the field conditions must be approximated as nearly as possible. With varying soil compositions, temperature, light and water relation and a bacterial flora varying in species and vigor, the conditions are very complex and no laboratory tests can ever entirely represent them. It must, however, be the aim of the Soil Bacteriologist to approach as nearly as possible the ideal. *One imperative step is the testing of the activities of soil bacteria in soils rather than in solutions.*

SUMMARY.

(1) Many soils which can nitrify ammonium sulphate and cottonseed meal mixed with them, fail to nitrify ammonium sulphate and cottonseed meal when used as the inoculum for solutions, such as those of Omelianski, Wiley, and Ashby.

(2) Nitrification is *nil* or very slight in saturated soils.

(3) Nitrification in some soils proceeds as fast as ammonification, converting the ammonia to nitrate as fast as it is rendered available by the ammonifying organisms.

(4) Nitrification in extract of soil is, in some instances, very slight as compared with nitrification in the soil itself.

(5) Nitrification in soils increases in intensity with the amount of inoculum used.

(6) Some nitrifying soils do not nitrify when placed in solutions even though a very large inoculum is used.

(7) Nitrifying organisms from sewer beds nitrified better in solutions than in soils.

(8) Tests in solutions are not adequate to indicate the nitrifying vigor of a soil.

THE COLORIMETRIC DETERMINATION OF NITRATES IN SOIL SOLUTIONS CONTAINING ORGANIC MATTER.

BY W. A. SYME.

The accurate determination of nitrates in soil solutions by the colorimetric method with phenoldisulphonic acid and ammonia is a matter of some difficulty on account of the large number of interfering substances which may be present in the solution. Chlorides may cause a loss of nitric acid when the phenoldisulphonic acid is added to the residue left on evaporation. Iron salts affect the color. Nitrites interfere by producing a yellow color with the reagents like that caused by nitrates. These disturbing factors can be removed to a considerable extent—the chlorides by adding silver sulphate, the iron salts with sodium carbonate, and the nitrites may be determined separately by the Griess method.

The presence of organic matter in the soil extract causes trouble in several ways. In the first place, the solution may be so intensely colored that it can not readily be decolorized with carbon black; secondly, the organic matter may reduce the nitrates, thereby causing a loss of nitric acid; and thirdly, the strong acid acting on the organic matter produces substances of foreign color which can not be matched by the pure nitrate standards.

The object of the work reported in this paper was to see if potassium permanganate could be used to remove organic matter from soil extracts. The extracts were prepared for some work on nitrification now in progress in this laboratory, the method of preparation being as follows: 400 grams of soil were shaken four hours with 1,200 cc. of water containing a little chloroform. The solutions were filtered through a porcelain tube.[1] The filtrates were strongly colored when the soils contained much organic matter. The solution from soil 1867, a soil from a compost heap and the one most favorable for the nitrification experiments, was very rich in organic matter and could not be satisfactorily clarified by shaking with carbon black. When this solution was evaporated to dryness, the residue treated with phenoldisulphonic acid and made alkaline with ammonia, the resulting solution had a brownish yellow color quite different from the clear lemon-yellow given by a pure nitrate solution.

The method for treating this solution, and others of the same kind, was as follows: Heat 50 cc., or any convenient portion to 60-70 degrees, and add 1 cc. of dilute sulphuric acid (1:5). Add from a burette a dilute solution of potassium permanganate (5 to 10 gm. per liter) until in excess and heat fifteen minutes on a water-bath, adding more permanganate from time to time, if necessary to have an excess. Remove the brown precipitate by filtering into an evaporating dish, make the filtrate slightly alkaline with sodium carbonate and evaporate to dryness on the water-bath. Add water to the residue and filter into a 50 cc. flask, wash the residue on the filter, and dilute to the mark. We now have 50 cc. of a colorless soil solution nearly free from organic matter. Nitrates can now be determined by the usual colorimetric method, remembering that if nitrite were present in the original solution, it would be oxidized to nitrate.

---

[1] Bulletin 31, Bureau of Soils, p. 12.

If a soil solution, after treatment in the way described, is evaporated and the color, developed in the usual way, is compared with that given by a portion of the same solution not so treated, the difference is very marked.

The evaporation of the soil solution with sodium carbonate removes manganese and iron, but enough nitrous acid may be taken up from the air to give an appreciable color with the nitrite reagent.

Carbonaceous matter was not entirely removed by the treatment with permanganate, though the coloring matter was destroyed and the residue left on evaporating the solution to dryness on the water-bath was colorless. The quantity of carbonaceous matter left by the permanganate was not enough to cause serious trouble when the phenoldisulphonic acid was added. The effect of the permanganate treatment can be readily seen by evaporating equal volumes of the same soil solution with and without permanganate and comparing the residues as to color, quantity of organic matter and behavior on ignition.

The method was tested by having an associate to prepare a number of solutions by adding known quantities of nitrate to soil extracts containing organic matter and giving them to the writer for analysis. The results were satisfactory in every case, and the method is now used in this laboratory.

Experiments were made to find out whether nitrate is formed by the oxidation of the organic matter by the permanganate. Soil extract 1931, containing organic matter but no nitrate or nitrite, was treated with permanganate. No nitrate was found after the treatment. A trace of nitrite from the air was found after evaporating the alkaline solution, but none was found in the acid solution before evaporation.

A liter of a colored soil extract was heated and acidified, permanganate was added in excess to the hot solution and the brown precipitate was filtered off. The filtrate was made alkaline with sodium carbonate, divided into two parts, and evaporated. In one part, nitrogen was determined by the Kjeldahl method, and in the other part by the Kjeldahl method modified to include nitrates. The same quantity of nitrogen was found in the two portions, showing that there had been no nitrate formation. This experiment was repeated with a pasture soil containing 50 per cent volatile matter, chiefly in the form of cow manure and vegetable mould. The result was the same, namely, there was no nitrate formation from the action of the oxidizing agent on the organic matter. It is therefore safe to use permanganate for the purification of soil extracts for the nitrate determination.

NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

By F. L. STEVENS and J. G. HALL.

ALFALFA.

Leaf Spot (*Ascochyta medicaginis* Bres).—This disease was found in abundance and did considerable damage in fields in Wake County. It has not been reported in America before, and is a new parasite upon alfalfa.

APPLE.

Bitter Rot (*Gleosporium fructigenum* Berk).—This disease was reported from Buncombe, Haywood, Stokes and Wilkes counties. The amount of damage is estimated at from twenty to seventy-five per cent of the crop.

Black Rot (*Sphæropsis Malorum* Peck).—Specimens of this disease were received for determination and advice from Sampson County.

Black Rot Canker (*Sphæropsis Malorum* Peck).—Apple twigs were received from Paul Cable, of Greensboro, with a statement that his trees were very seriously affected, some of them killed. Microscopic examination revealed only the presence of *Sphæropsis Malorum,* but this in considerable abundance. Apple twigs affected with the Black Rot Canker were also received from Mr. Howard, Salemburg, with a statement that they were from a young orchard of one hundred and ninety trees, twenty-six of these trees being seriously affected with this canker, one dead, and four or five others nearly dead. Another package was from an older orchard of sixty trees, in which some three of the young trees were affected and four or five of the older trees.

The canker differed from any other canker which has come under our observation, the chief point being an intense black color over the bark, and the presence of abundant spore-bearing pustules. The diseased portion is usually divided from the healthy by a sharp, definite line, and the diseased portion stopping in growth before the healthy above and below it, is nearly always of smaller diameter, giving striking appearance of constriction. On cutting into the wood of the diseased region, it was found to be blackened, often to the center, and this blackening frequently extended a long distance, both above and below the cankered portion. Microscopic examination showed this blackening to be due to the presence of a black mycelium in the diseased tissue, this mycelium having all the characteristics of that of *Sphæropsis.* On some of the cankers *Sphæropsis* only was found; on other cankers, an ascomycetous fungus only, while in other instances both the Ascomycete and *Sphæropsis* were present.

Blotch (*Phyllosticta*).[1]—For several years this disease has been noticed in many portions of the State, on apple twigs, forming small cankers. The fungus appears to be identical with that described as the "blotch," so abundant and destructive in Arkansas on the fruit and foliage of the apple. Strange to say, however, in North Carolina our attention was not called to this fungus affecting fruit and leaves until March 3, 1908. A letter was then received from M. L. Willard, of High Point, in which he states: "I wish to consult you about my apple trees. They look thrifty and bear well; about the middle of July they begin to shed some of their leaves; about the same time I discover little black specks on the apples. About the middle of August they begin shedding their leaves again, and by that time the black specks have grown till the apple is about decayed. By the middle of September the leaves are all off. By that time you hardly find an apple but what is decayed or partly decayed. The trees I am speaking of are the Red Limbertwig. I have in the same orchard some May apples and some harvest apples that mature well."

From this description it seems probable that this is an actual occurrence of the blotch in a very destructive form on the fruit in North Carolina.

Canker (*Phyllosticta*).—The canker upon the bark of apple twigs has been under observation for several years. It usually begins upon the one year old twigs, where the canker first appears as yellowish, brown spots, in the central region of which are scattered very minute spore bearing pustules. As the canker becomes older, it encroaches upon the fresh bark around the original canker; the bark ruptures and a considerable portion becomes roughened. The spores from the pycnidia show the fungus to belong to the genus *Phoma* or the genus *Phyllosticta*.

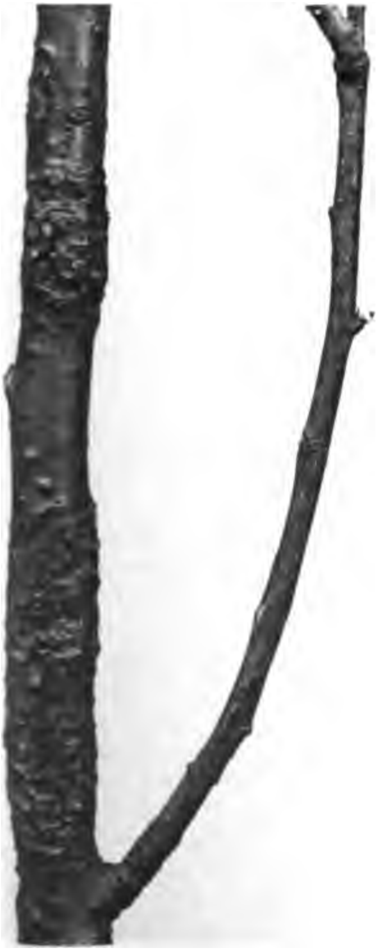


Fig. 1.—Apple Canker, Pyllosticta. At right, one year old twig showing several young cankers; at left, older twig showing more mature and rougher canker.

---

[1] This is the species reported by some pathologists as P. *solitaria* E. and E.

It is unquestionably the fungus called *Phyllosticta solitaria* by various authors, and which has been reported as being extensively destructive upon the fruit of the apple in several States, notably in Arkansas. It is noteworthy that so far as our observations go, this fungus, while widely distributed upon the twigs, does little or no damage upon the fruit itself here unless in exceptional cases.

Aside from finding this canker abundant in Wake County, specimens were also received from Madison and Henderson counties.

FIREBLIGHT (*Bacillus amylovorus* (Bur). De Toni).—This disease was noted in a very destructive form in nearly all of the counties visited on the Farmers' Institute trip. In many instances single trees were killed; in some instances, whole orchards. Specimens were received during the year from Iredell, Buncombe and Sampson counties.

HYPOCHNOSE.—This disease, not heretofore recognized in the United States, was collected in the following places in North Carolina: Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola and Mt. Airy. It produces a rotting of the leaves, in which condition they have a tendency to droop and mat together. These diseased leaves are accompanied by brown, fibrous or globular sclerotial formation upon the twigs.

LEAF SPOT (*Phyllosticta. sp.*).—Leaf spots, consisting of brown dead tissue, occur in all portions of the State. It is customary to attribute these spots to a species of *Phyllosticta*. Whether they are all due to the same species, or indeed whether they are all due to *Phyllosticta* at all or not is an open question. In any even, the leaf spot abounds in North Carolina wherever the apple is grown, being, in general, very much worse in the mountains than in the more eastern sections of the State. The leaf spot consists of circular regions of dead tissue, sharply bounded from the healthy tissue. In the older spots there is a characteristic concentric arrangement of irregular circles. This disease is al-

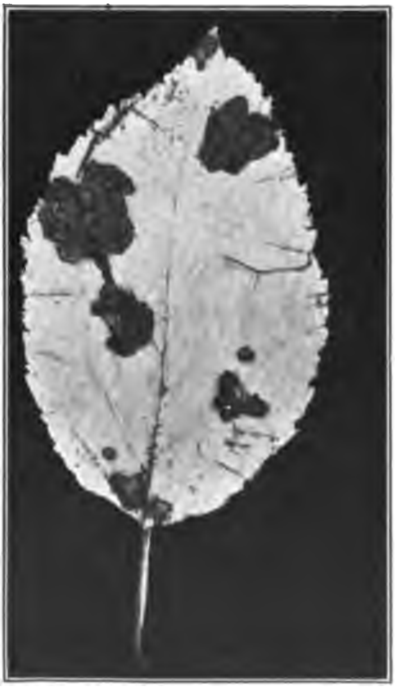


FIG. 2.—Apple Leaf Spot, in late stage of development, showing concentric rings.

most entirely held in check by proper spraying. Specimens were received from the following counties: Rowan, Guilford, Davidson, Vance, McDowell, Greene, Burke, Iredell, Wake, Henderson and Surry.

MONILIOSE (*Monilia fructigena* Pers.).—This fungus was found upon apples sent to the Station by B. F. Sparger, of Mount Airy, many of the fruits submitted by him developing well marked, characteristic cases of *Monilia* rot after remaining in the laboratory for a few days. The fungus, from measurements and appearance, agrees entirely with *Monilia fructigena*. This is the first record of the occurrence of this disease in North Carolina, although it has long been seriously destructive in Europe. It has been reported from the following States: Arkansas, Nebraska, New Mexico, Virginia, and West Virginia. The disease was particularly abundant in the portion of the orchard adjacent to plum orchards, where the Japanese and Abundance plums had been very seriously affected with this fungus the preceding spring.

RUST (*Gymnosporangium, sp.*).—The apple rust is much worse in the Piedmont and the coastal section than in the mountains. It was seen in an especially destructive form this year in Brunswick and Durham counties. Specimens were submitted this year from the following counties: Franklin, Wake, Halifax, McDowell, Burke, Rowan, Iredell, Cabarrus, Mecklenburg and Surry. Its winter stage upon the cedar tree is a familiar sight in spring, throughout the eastern and central portions of the State, most of the cedar trees being thickly hung with cedar balls, protruding from which are the well-known gelatinous honey-colored horns. This disease is said to be more severe upon the Tawny and the Horse apples.

SCAB (*Venturia inæqualis* (Cke.), Wint).—Specimens of this disease upon the fruit and also upon the leaves where it appears as black, sooty spots, were received this year for determination from Buncombe, Iredell and Moore counties.

BEANS.

ANTHRACNOSE (*Colletotrichum Lindemuthianum* (Sac. & Magn.), Bri. & Cav.).—This anthracnose occurred in considerable quantity on the College farm and other places in Wake county. Reports were received from Montgomery and Iredell counties. One report says that 90 per cent of the pods were diseased. In October a large quantity of diseased pods was gathered, brought to the laboratory and dried, for the purpose of study.

RUST (*Uromyces appendiculatus* (P) Lav.) was collected in Davidson and Catawba counties.

CANTALOUPES.

DOWNY MILDEW (*Peronospora Cubensis* B. & C.).—This disease is identical with the mildew of the cucumber and may be expected anywhere that the cucumber disease is found.

Nematodes (*Heterodera radicicola* (Greef), Mul.).—Specimens of cantaloupes very badly galled by nematodes were received in September from R. A. Parker, Duplin County. The roots were galled from end to end, the galls being exceedingly large and abundant. Referring to the injury done, he says: "We planted five acres. They came up and grew off at first better than my neighbor's in an adjoining field, but about the time they began to run they began to turn yellow, and lots of them finally died. A good many that did not die did not produce any fruit. We gathered 500 crates from the five acres and my neighbor in adjoining field gathered 600 crates from three acres." Specimens of roots from the "adjoining field," mentioned above, proved to be entirely free from nematodes, and it is probable that the discrepancy in yield between these two fields is to be attributed to these nematodes. The disease is apparently very widely distributed through the State, often doing much damage.

CARNATION.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Roots affected with nematode galls were sent to the Station for determination from Wake county.

CAULIFLOWER.

Black Rot (*Pseudomonas campestris* (Pam), Smith).—Specimens of cauliflower thickly covered with densely black spots were observed upon the open market in Raleigh. The disease was exceedingly conspicuous, owing to the intense black spots upon the white background furnished by the healthy portions of the cauliflower. Upon examination it was found that the black spots were due to bacteria, which had all the appearance of being the usual form causing the black rot of the cabbage. The vascular bundles, leading from the spots toward the center of the head,

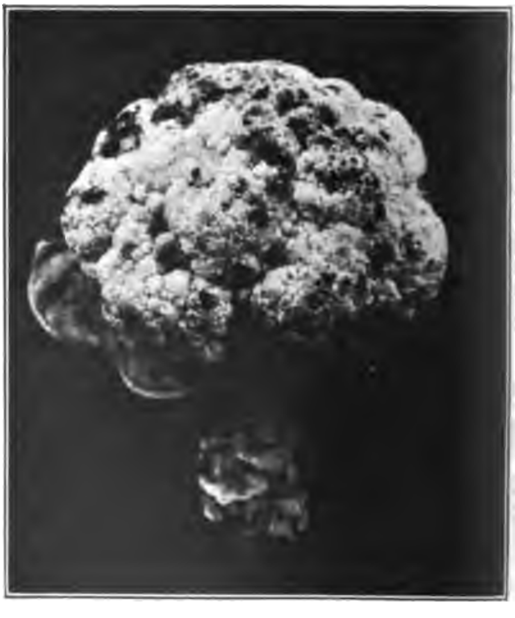


Fig. 8.—Cauliflower Black Rot (Pseudomonas campestris). The blackened spots are caused by this bacterial rot.

were blackened in a manner characteristic of vascular bundles of plants affected with black rot, and it seems clear that this disease is identical with the cabbage black rot.

From the appearance of the disease it seems certain that the infection was from the surface and the disease was progressing inward. Upon inquiry, it was found that the diseased cauliflower was shipped from Washington, N. C., and it was impossible to ascertain where they were grown. The occurrence of this disease in this fashion is of much interest to North Carolinians, since it shows one manner in which it may gain access into and distribution through the State.

CELERY.

Leaf Spot (*Septoria petroselina* Desm. var. *apii* Br. & Cav.).—This disease made its appearance in a very destructive form in gardens in Wake county this year, causing the loss of the whole crop in many instances. The leaves turn yellow, and then, upon closer examination, are found to have black dots, pycnidia, upon them. This disease may be held in check by spraying with Bordeaux mixture.

CHRYSANTHEMUM.

Leaf Spot (*Septoria Chrysanthemi* Cav.).—This diseased specimen was sent in for determination from Cumberland county.

CHERRY.

Shot Hole Disease (*Cylindrosporium padi* Karst).—This disease abounds in all sections of the State. It was collected particularly this year in Brunswick, Wake and Halifax counties, and specimens were sent in for determination from Guilford county.

COLLARDS.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—Collards affected with this disease were collected in Wake county by B. B. Higgins.

COTTON.

Anthracnose (*Colletotrichum gossypii* South).—Cotton anthracnose has been particularly abundant this year. Specimens were received from Cleveland, Wake, Craven, Montgomery, Beaufort, Iredell counties, and letters of inquiry concerning it were received from Richmond and Scotland counties. In many instances people writing concerning cotton anthracnose in their fields this year stated that the only portions affected upon their plantations were fields which were planted with seed from some distant source, it being frequently stated that the seed producing the anthracnosed crop came from Georgia. The frequency with which such observations were made agrees well with the generally accepted idea that the fungus causing the anthracnose may be carried from one crop to the next upon the seed, and it serves to emphasize the importance of avoiding seed which comes from infected fields, and of knowing the character of the field from which seed does come, so that the grower may be certain that the seed which he has purchased came from a healthy, not from a sick field.

AEROLATE MILDEW (*Ramularia areola* Atk.).—The frosty mildew affects the leaves, producing small, angular spots, which are first pale green, then turning light yellow and pale brown. Upon the under side of the leaf, in the early stages of this disease, small spots covered with a frosty white growth are seen. The disease is seen in most cotton fields examined, but usually it is of no very great importance, although in some instances, if the leaves become much spotted, the whole leaf will become weakened, will turn yellow and fall off. In this way the disease sometimes becomes to some degree serious.

BACTERIAL DISEASE (*Bacillus Malvaccarum* Erw. Smith).—Specimens of this disease were collected in Wake county. The disease was not noticeable in particularly destructive form. In seriousness it seems to be about equal to the frosty mildew, which in many ways it very closely resembles in general appearance.

WILT (*Neocosmospora vasinfecta* (Atk.), Erw. Smith).—Several complaints of cotton wilt from isolated sections of the State were received this year. This disease is undoubtedly widespread throughout the cotton section of the State, although in many instances the territory of the individual fields which are invaded is not very large. The disease, however, is constantly spreading, and is one which should be carefully guarded against by cotton growers.

COWPEA.

LEAF BLIGHT (*Cercospora Dolichi* E. and E.).—This leaf blight prevails nearly everywhere the cowpea grows, producing a spot which. viewed from below, is angular and is of a uniform ashen, dirty color. The spot is surrounded by a region of the leaf, which is pale yellow in color. Many spots upon the leaf result in its premature death and cause it to fall off.

LEAF SPOT (*Amerosporium œconomicum* E. & T.).—This disease is readily distinguished from the last by the fact that the spots are circular and are studded all over with little black specks smaller than the ordinary pin hole. The spots of this are also of shining whiteness, and in this character are quite readily distinguished from the Cercospora spot. The disease is often abundant, but is usually not so serious as is the Cercospora.

ROOT KNOT (*Heterodera radicicola* (Greef), Mul.).—Plants badly affected with root knot were collected in Wake county. This disease may be overcome by using the Iron variety of cowpeas, which is resistant to the disease.

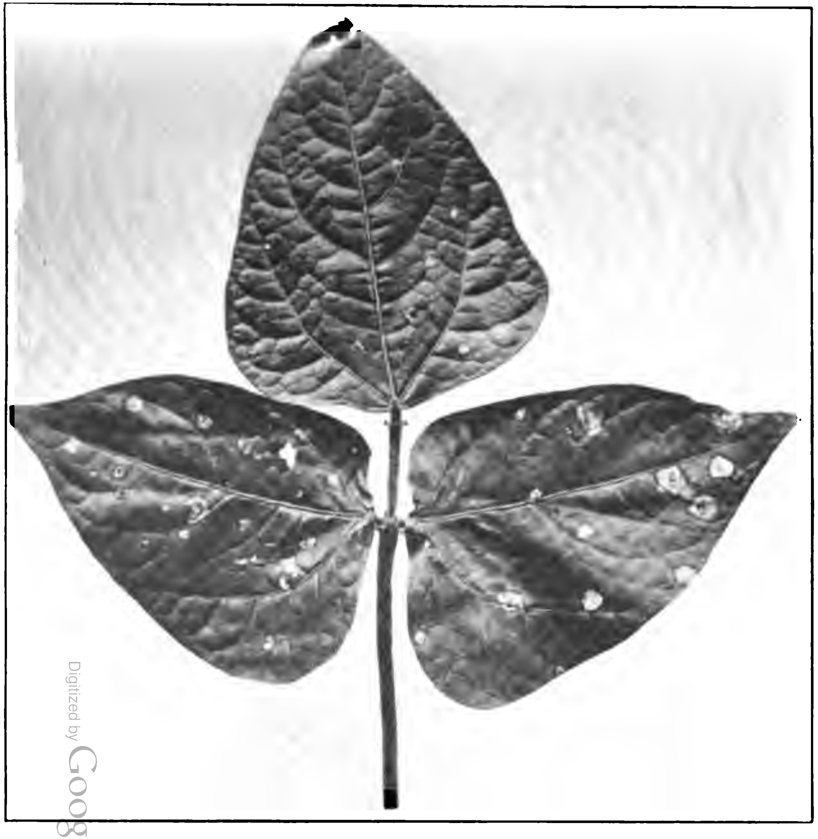


FIG. 4.—Cowpea. Leaf Spot (Amerosporium).

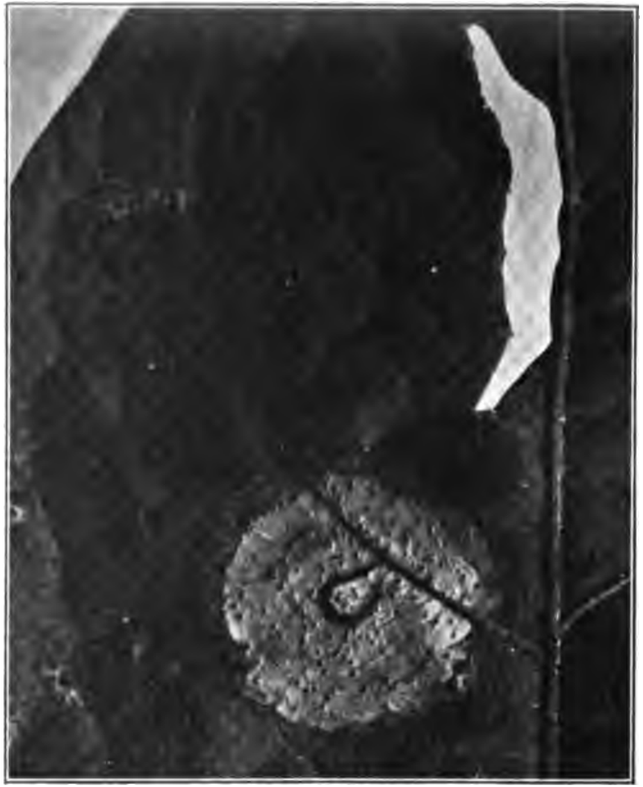


FIG. 5.—Cowpea Leaf Spot (Amerosporium). Abundant spore bearing pustules scattered throughout the circular spot (enlarged four diameters).

CUCUMBER.

Downy Mildew (*Peronospora Cubensis* B. & C.).—The downy mildew, which has proved so destructive to cucumbers in other States, in South Carolina so injurious as to almost destroy the cucumber industry in certain sections, has begun to make its appearance abundantly in North Carolina. Specimens were collected this summer in Wake, Wayne, Cabarrus and Alamance counties. This disease is recognized by the yellowish angular spots as shown from the upper side of the leaf. The spots enlarge until the whole leaf is involved, and it soon droops and dies. This disease has given way in other States to careful spraying, and would probably do so here.

DEWBERRIES.

Septoria rubi West.—Specimens were received for determination from Moore county.

GRAPES.

Black Rot (*Guignardia bidwillii* (Ell.), V. & R.).—This disease is abundant throughout all portions of the State and upon all varieties of bunch grapes. The scuppernong is almost immune and is only rarely found with a single spot of black rot. Specimens of black rot on the bunch grape were received from Buncombe, Halifax, Pender, Burke and Moore counties.

GRASS.

Myxomycete (*Physarum cinereum* (Batsch), Pers.).—In several instances grass has been known to be affected with a species of Myxomycete. The fungus causing this damage has been determined by McBride as *Physarum cinereum*. The damage begins in the diseased spots in the lawn or field, in which the grass plants become totally covered with the fruiting organs of the fungus, so that when viewed from a distance of a few feet nothing but a black spot is seen, the grass being entirely hidden by the slime mold growing over it. The spot rapidly enlarges, often becoming several yards in area. This disease was noted a year ago at Raleigh, and it became so serious at Waynesville and Oxford that specimens were sent in for determination and advice this year. It may be mentioned that the same fungus has also been noticed as a parasite on grass in Montgomery county, Penn.[1]

LETTUCE.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—This fungus made its appearance upon the lettuce beds of West Raleigh, where it was first seen by B. B. Higgins on November 26. The sick plants collected and brought into the laboratory developed the characteristic symptoms of sclerotinose. There is no record that this fungus existed in this place before, and its occurrence is noteworthy as a possible indication that the fungus was already in the soil, subsisting naturally on some other host plant.

---

[1] A Grass-killing Slime Mould. By John W. Harshberger, Ph D., Proc. Am. Phil. Soc. XLV, Nov. 3, 1906.

PEACH AND PLUM.

Cornularia Persicæ (Schw.), Sacc.—This peculiar fungus was noted in every portion of the State where examination for it was made. Specimens were collected in abundance in Wake and Lenoir counties. It probably does little or no damage to the trees.

PEACH CURL (*Exoascus deformus* (Berk.), Fckl.).—Specimens were received for determination from Granville county. This disease is almost completely controlled by spraying with Bordeaux mixture before the buds open.

PEAR.

BLACK ROT CANKER (*Sphæropsis malorum* Pk.).—Specimens of badly cankered pear limbs were received from S. C. Godwin, Fayetteville, on December 13. Microscopic examination showed the presence of mycelium and fruiting pycnidia of *Sphæropsis* in great abundance. Godwin writes: "Some of my trees are dead and all except one are so badly affected that they can hardly survive."

This is the first complaint that we have had of *Sphæropsis* as a very destructive canker-producing fungus on pears in this State, although the fungus is exceedingly common upon the apple. Specimens showing injury from this disease were also received from Cumberland and Alexander counties.

BLIGHT (*Bacillus amylovorous* (Burr.), De Toni).—This blight was even more destructive than the apple blight, as is usually the case, and is present in the State practically everywhere that pears are grown, and upon nearly all varieties. One variety, known as the Florida Sand Pear, raised by N. W. Herring, LaGrange, N. C., possesses a very high degree of resistance to this disease. On inspection last year this variety was seen to pass entirely unscathed, while adjoining Keiffers were very seriously affected. Specimens were received from Mecklenburg, Jackson, Randolph and Moore, and inquiries from Catawba, Franklin, Richmond and Vance counties.

LEAF SPOT (*Septoria piricola* Desm.).—Pear trees badly infected with the leaf spot were noted in Brunswick county, about twenty miles from Wilmington, in the summer of 1907. The trees were so badly infested that every leaf bore one or more spots, while many of the leaves had a dozen or more each. The spot was exceedingly characteristic, being of a pale, ashen color, with a very definitely limited border. It was angular in outline and limited by the veins. The spots were small, ranging from two or three to six or eight millimeters in diameter, and usually bore one, two or three small black specks, which upon microscopic examination proved to be pycnidia. In section, the pycnidia are seen to be deep-seated, only the mouth projecting above the epidermis. In appearance they agreed exceedingly well with the drawing given by Atkinson in Bulletin 145 of the Cornell Experiment Station. The cavity of the pycnidium was filled with rather long, curved, crooked or crescent-shaped spores, which exhibited a strong tendency to adhere together in compact masses. These spores have the characteristic shape, form and septation of *Septoria*. Most of them were continuous, though very rarely spores with one, or occasionally two septa were seen. In striking distinction, however, from the usual *Septoria*, and from the genus as defined, these spores were dark in color, agreeing thereby with the genus *Hendersonia*. The possession of dark spores seems, however, to be permitted to *Septoria* in the species *Septoria piricola* Desm., which is, in all probability, the species in hand.

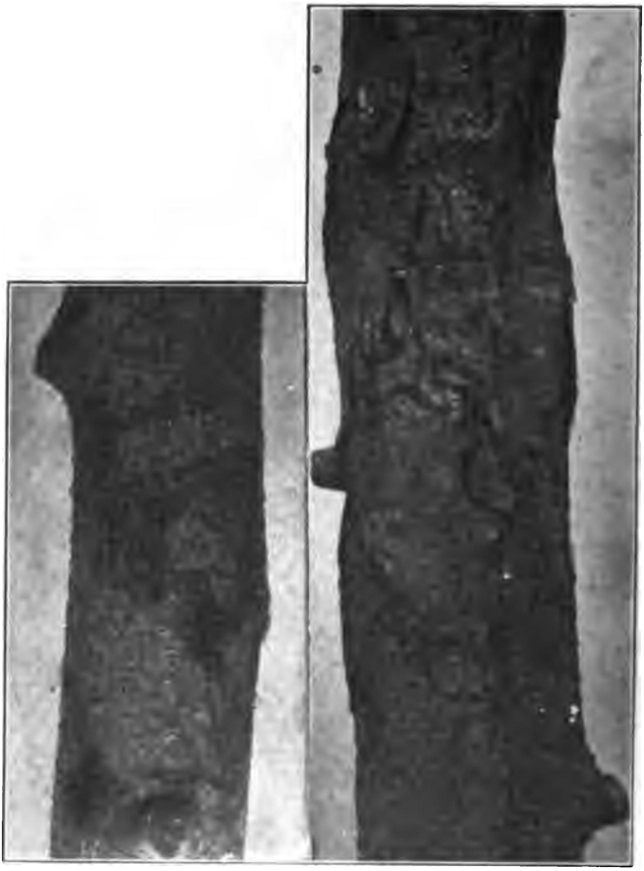


FIG. 6.—Pear Canker (Sphæropsis). At right, the cracked bark of cankered portion. Minute spore bearing pustules are apparent in certain portions. At left, bark thickly beset with spore-bearing pustules.

POTATO, IRISH.

Scab.—The prevalence of this disease in the State is not well known. It is probably abundant. Specimens were collected this year by B. B. Higgins at Newton and Eufola.

POTATO, SWEET.

Dry Rot.—A rot of the sweet potato, consisting of sunken, somewhat shriveled, dried, brownish areas, has been repeatedly reported to the Station this year for diagnosis and advice. The accompanying illustration shows the appearance of the potato, both from surface view and in section. It is noticed that the rot penerates to considerable depth into the potato.

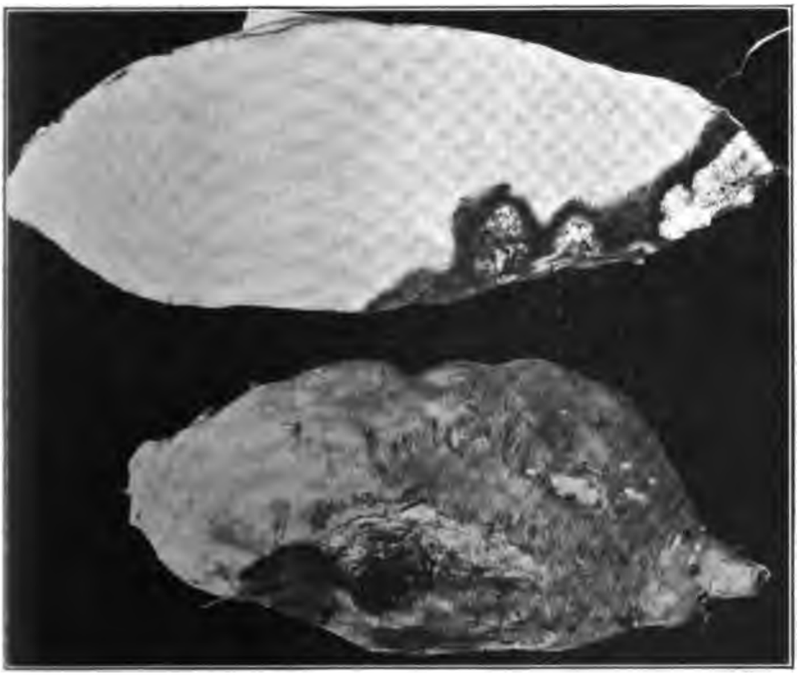


Fig. 7.—Sweet Potato Dry Rot. Below is shown shrunken, shrivelled, brownish, diseased region: above is shown a longitudinal section, and the depth to which the disease penetrates.

Observations in the laboratory show that the diseased spots enlarge slowly, as time passes, yet with sufficient rapidity to cause the spot to change from a small one to a very large one in the interim between housing and springtime.

In culture this condition of disease always gave a *Fusarium*, which was accompanied by a *Nectria*, apparently identical with *Nectria Ipomoeæ*, mentioned by Halstead[1] as causing a rot of the sweet potato. While the fungus seems to be the same one noted by Halstead, we do not feel sure that the rot with which we are dealing is the disease which he studied.

---

[1] N. J. Agr. Exp. Sta. Rept., 1891, p. 281.

Specimens of potatoes affected with this disease were received from L. C. Ellington, Madison county, January 8, 1908; J. M. Garrison, Gaston county, and A. B. Cooper, Beaufort county.

The relation of the fungus to the disease is still the subject of study here. The indications at present are that this is a soil disease and that it is not advisable to raise potatoes successively on fields where this disease has shown itself.

LEAF SPOT (*Phyllosticta bataticola* Ell. & Mart.).—The *Phyllosticta* spot is present in sweet potato fields generally, but it is probably not of serious import.

WHITE SMUT (*Albugo Ipomoeæ panduranæ* (Schw.):—This is found frequently, though it is not exceedingly common upon the sweet potato. The injury from it is trifling.

QUINCE.

RUST (*Gymnosporangium*).—This rust, the same that affects the apple, winters likewise upon the cedar tree. Specimens were received for determination from Moore county.

ROSE.

BLACK SPOT (*Actinonema rosæ* (Lib.), Fr.).—Specimens were received from Warren county.

BLOSSOM BLIGHT.—Attention has been repeatedly called to a disease of roses, which appears in very destructive form. The disease manifests itself in the failure of the buds to open. The buds mature in apparently normal condition, until they become about one inch long, the outer petals then show signs of wrinkling, the first indication of the disease. The buds continue to expand somewhat, the outer petals begin to turn yellow or straw-colored, and soon all development ceases. In some instances the buds partially open, but as a rule they do not attain a size of more than 1¼ inches, and the petals do not really open at all. In most instances where the disease is noted it occurs on several buds on the bush. The character of the disease in single buds is shown in Fig. 9.

In a short time after the disease becomes evident in the bud, all development ceases, petals die, and the line of absission between the pedicil and the stem becomes marked, and the flower may be easily separated from its stem at this point. The whole bud soon dries up, its stem, down to the line of absission, likewise shrivels and dries, and the occurrence of the disease remains conspicuous by the presence of dry, straw-colored, dead buds upon the bush.

The disease is known to recur season after season on the same bush, while other bushes in the immediate vicinity, growing in the same soil and climate, are free from infection.

Close microscopic examination failed to reveal the association of any fungi or bacteria with this disease. It seems, therefore, that it must be, for the present, classed as a "physiological disorder," brought about by some unknown cause. It is possible that it is hereditary and that avoidance of stock subject to this disease may lead to the removal of the difficulty.

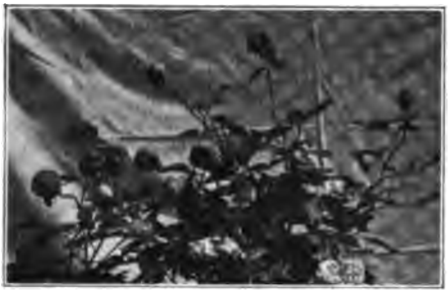


FIG. 8.—Rosebud Blight, showing destructive nature of the disease on individual bushes; every bud is diseased.

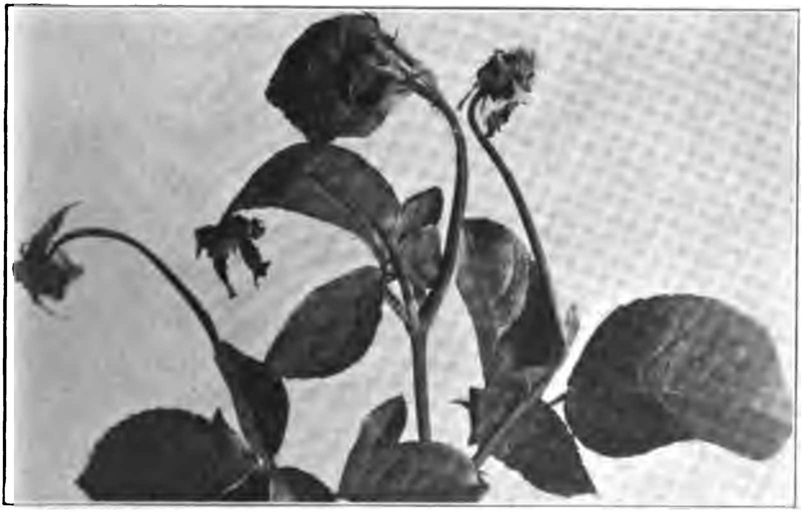


FIG 9.—Rosebud Blight, showing withered bud and dry, dead condition of the peduncles.

MILDEW (*Sphærotheca pannosa* (Wallr.), Lev.).—This disease is one concerning which probably more queries have been received than regarding any other plant disease of the State. The Mildew makes its appearance early in the spring, almost as soon as the leaves come out, as a white, dusty powder over the surface of the leaves, stems and buds.

The leaves so affected fail to develop properly, roll or curl up, the buds fail to open, and the growth of the plant is stunted. The appearance of such a diseased twig, as contrasted with the healthy twig, is well illustrated in Fig. 10. Concerning this disease this year, queries and specimens have been received from the following counties: Halifax, Cleveland, Durham, Warren, Iredell and Granville counties. Queries without specimens were received from Chowan county.

The rose mildew may be readily prevented or held in check by use of the various spraying mixtures. Probably the Bordeaux mixture is most to be recommended, unless the bush is so located that the use of the Bordeaux mixture would be undesirable, such as would be the case, for example, if the rose bush grows near a white house in such position that the Bordeaux would spot the house in an unsightly way. In such event, either liver of sulphur, one ounce in three gallons of water, or the ammoniacal copper carbonate may be substituted.

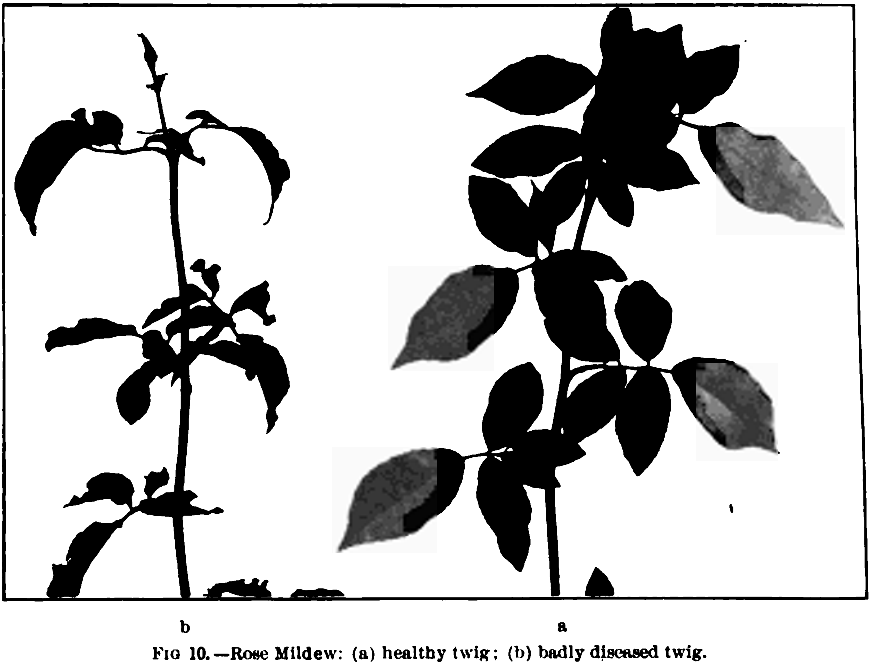


FIG 10.—Rose Mildew: (a) healthy twig; (b) badly diseased twig.

SORGHUM.

SMUT (*Sphacelotheca sorghi* (Link), Clint.).—A smut attacking the flowers and fruit, but not the stalk or leaves, was found in Wake county, but not in such quantities as to be of any serious damage.

SQUASH.

(*Fusarium,* sp.).—Garden squash were seriously diseased in some instances, the vines appearing stunted, pale, and later dying. Upon miscropic examination, the vascular bundles were seen to be invaded by a fungus, which proved to be a species of *Fusarium.* The disease had all the characteristics of the ordinary wilt and was apparently caused by this fungus, which is one of the most common of the wilt-producing fungi. Whether the fungus be identical with that causing the wilt of cotton, melons, etc., was not determined, though no differences were noted.

SYCAMORE.

POWDERY MILDEW.—A powdery mildew has been noticed affecting the leaves of the sycamore seriously in early spring. Leaves are attacked long before they reach the mature form and structure, presenting very much the appearance of frost injury. The affected spots are blighted, fail to grow, turn dark in color. Owing to their failure to grow, the leaf becomes wrinkled, curled, and distorted. Examination of the affected spots shows them to be densely overgrown with the conidial stage of a powdery mildew. While no mature fruiting organs have been found, and it is impossible to make a complete determination of the fungus in its conidial stage, it agrees entirely with the description of *Microsphæra Alni,* which is reported as growing upon this host. The fungus is especially noteworthy from its attack early in the season upon leaves before they have completed their development.

TOBACCO.

FROG EYE (*Cercospora Nicotianæ* E. and E.).—Specimens were collected in tobacco barns at Greenville. The disease is probably generally prevalent.

GRANVILLE TOBACCO WILT.—This disease, hitherto unknown in literature outside of Granville county, was noted this year in Durham and Vance counties, and specimens, which seemed almost certainly to be this disease, were received from Quincy, Fla., where, says Shamel, "they are doing immense damage."

At Graystone, N. C., July 22, on the farm of James A. Tunstall, Ashe county, two small fields were noted where the wilt occurred. In one instance, out of six hundred plants counted, two hundred showed the typical disease, and it was apparent that about the same percentage prevailed throughout the field. Mr. Tunstall stated that he had known this disease in his tobacco for more than twenty-five years, and has been obliged to abandon a great deal of his tobacco land on account of its occurrence. According to his experience, the land affected with the wilt, left without tobacco for ten years, is still diseased, and if planted again at the end of that time, with tobacco, results in the loss of a large percentage of the crop.

One farmer in the neighborhood lost his entire crop through this disease. There came under our personal observation one field of which it was stated that tobacco had not been planted on that field for at least twenty-five years, the field, however, was very badly wilted.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Many complaints were received concerning the root galls upon tobacco; notably from Whiteville and Washington. These galls are caused by minute worms or nematodes similar to the vinegar eel. These worms abound in the soil and from it enter the roots of the plants and cause the gall to develop. In many instances they do not seem to cause serious loss, but in other instances they are very destructive to the crop. The only remedy is to so rotate the crops as to avoid planting susceptible crops upon soil bearing nematodes.

There is always a possibility of finding tobacco plants which possess a resistance to the worms. If such plants are noticed, seed from them should be saved with great care with the hope of building up a disease-resistant variety.

TOMATO.

Blight (*Bacillus Solanacearum* Erw. Smith).—This bacterial disease of the soil which causes a dying of all tomatoes placed in it, unifortunately claims many fields of the State, and it is constantly spreading into new territory. It was noted in its usual abundance this year.

Blossom End Rot (*Fusarium Solani* (Mart.), Saac.).—Specimens were received for determination from Pamlico county.

Leaf Spot (*Septoria Lycopersici* Speg.).—The *Septoria* is to be distinguished from the blight by the fact that the leaves when first infected are diseased in spots only, whereas, in the blight the leaf is not spotted, but droops and dies as a whole. The leaf spot usually affects the lower older leaves first. As the spots enlarge, encroaching upon the whole leaf, the leaf dies. Often the disease progresses so fast that the whole plant soon becomes involved. This disease may be controlled by spraying with the Bordeaux mixture.

VETCH.

Downy Mildew (*Peronospora viciæ* (B.), DeBy.).—This disease appeared upon cultivated vetch in Wake county this spring and did a great deal of damage. The plants affected did not develop normally, were much smaller, weaker and paler than the neighboring ones. Upon close examination the under side of the leaves was found to be covered with the fine down of *Peronospora*.

WATERMELON.

Wilt (*Neocosmospora vasinfecta var nivea* Erw. Smith).—Inquiries concerning this were received from Vance county.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

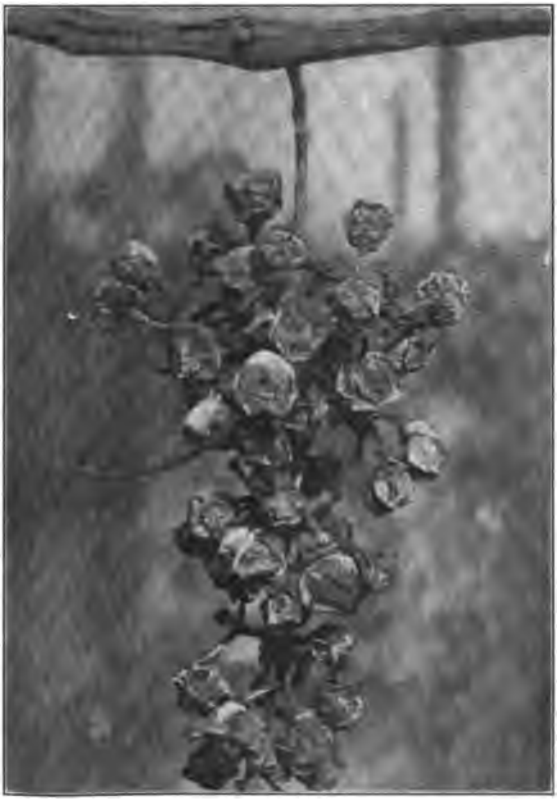
C. B. WILLIAMS, Director.

PRESS BULLETIN No. 17.—FEBRUARY 15, 1908.

THE GRAPE BLACK ROT.

This disease prevails in all parts of North Carolina. In most sections of the State it is so bad that the grape crop is practically ruined unless proper measures be taken to prevent the disease.

The black rot is easily recognized from the accompanying illustration showing its most conspicuous characters, blackening, drying and final shrivelling of the grapes in the clusters. Often all of them shrivel and dry in this way. Though the disease is seldom noticed until the grape is badly shrivelled, it may be seen earlier as a brown or black spot on the berry. Before its appearance upon the fruit at



all it may be found as brown spots, one-eighth to one-half an inch in diameter, on the leaves or twigs. Very close examination of the diseased spots on twigs, leaves or fruit, reveals the presence of very small pustules in great numbers.

These pustules are the fruiting bodies of the fungus which is the cause of the black rot, and from these pustules issue immense numbers of spores, which serve to spread the disease.

This disease can be prevented. If you saw black rot on your grapes last year it will almost certainly be there again this year, unless you take steps to prevent it. Prevention is simple and sure. It consists in spraying your vines with the Bordeaux mixture, consisting of six pounds of bluestone, four pounds of lime and fifty gallons of water. The first application, killing the spores that are wintering on the bark and trellis, should be made before the buds open; the second, immediately before the blossoms appear; the third, just after blossoming; the fourth and fifth at intervals of ten to fourteen days thereafter. .

The cost of six sprayings for an acre of grapes is about fifteen dollars, including material and labor. The grapes saved will in value far exceed this cost.

Now is the time of year to get your spray pump ready if you have one; to buy one if you need to; to prepare for the spraying needed during the coming spring.

If you need further information regarding spraying mixtures, how to prepare them, spraying pumps, where to buy them, and what crops and when to spray, write to the North Carolina Agricultural Experiment Station, West Raleigh, N. C., for Bulletin 193, "Spraying Mixtures and Machinery, When and How to Spray."

The following Bulletins of interest to fruit growers may be secured upon application:

Bulletin 184. Garden and Orchard Fruits, their Culture and Marketing.

Bulletin 185. Black Rot of the Grape in North Carolina and Its Treatment.

Bulletin 186. Insect and Fungous Enemies of the Peach, Plum, Cherry, Fig and Persimmon.

Bulletin 187. Grapes and Small Fruits.

F. L. STEVENS, *Biologist.*

Bulletin 197 MAY, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

SOME INSECT ENEMIES OF GARDEN CROPS

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

Governor R. B. Glenn, *ex officio* Chairman, Raleigh

R. H. Ricks	Rocky Mount	J. T. Ellington	Smithfield
W. D. Turner	Statesville	W. E. Daniel	Weldon
O. M. Gardner	Shelby	W. H. Ragan	High Point
Locke Craig	Asheville	W. B. Cooper	Wilmington
C. W. Gold	Raleigh	M. B. Stickley	Concord
E. M. Koonce	Jacksonville	T. T. Ballinger	Tryon
T. W. Blount	Roper	N. B. Broughton	Raleigh
D. A. Tompkins	Charlotte	O. L. Clark	Clarkton

STATION STAFF

George T. Winston, President of the College.

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
William Kerr	Assistant in Field Experiments
W. A. Syme	Assistant Chemist
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant in Farm Crops
J. C. Temple	Assistant Chemist and Assistant Bacteriologist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

TABLE OF CONTENTS

PAGE

Angoumois grain moth—*illustrated*.. 39

Aphis, cabbage 17

Arsenate of lead, preparation of..... 61

Arsenical poisons, names and formulas 60

Asparagus beetle, the common—*illustrated* 9

Asparagus beetle, the 12-spotted—*illustrated* 9

Bean, insects of................ 11-15
  cutworms injurious to—*illustrated* 11
  leaf beetle—*illustrated* 14
  weevils—*illustrated* 15
  wireworms injurious to......... 11

Beet, insects of................ 16, 17
  cutworms injurious to.......... 16
  flea-beetles injurious to......... 16
  leaf miner 16
  webworms injurious to—*illustrated* 16
  wireworms injurious to......... 16

Biting insects, general description... 8

Bordeaux mixture 61
  and arsenicals 61

Cabbage, insects of.............. 17-29
  aphis—*illustrated* 17
  cutworms injurious to.......... 17
  flea-beetles on................. 17
  looper—*illustrated* 26
  maggots—*illustrated* 28
  plutella (diamond back moth).. 27
  snake—*illustrated* 29
  terrapin bugs on—*illustrated*.... 18
  webworm—*illustrated* 23
  worm (imported)—*illustrated*... 20
  worm (native)—*illustrated*..... 22

Cantaloupe, insects of........... 40-46
  cutworms, injurious to......... 40
  cucumber flea-beetle on—*illustrated* 44
  melon louse—*illustrated* 40
  pickle worm on—*illustrated* 44
  red spider on.................. 40
  striped cucumber beetles on—*illustrated* 42

Carbolic acid emulsion for root maggots 47

Carbon bi-sulphid, uses of........ 39, 48

PAGE

Cauliflower, insects of (*See cabbage*), 17

Celery, insects of.................. 30
  caterpillar 30
  cutworms injurious to.......... 30
  lice on 31
  red spider injurious to......... 31

Chewing or biting insects........... 8

Collard, insects of (*See cabbage*), 17-29

Colorado potato beetle—*illustrated*... 49

Common names of young insects..... 7

Corn, insects of................. 31-40
  ear worm—*illustrated* 37
  root-worm or bud worm—*illustrated* 33
  stalk borer—*illustrated* 35
  weevils—*illustrated* 39
  wireworms injurious to—*illustrated* 31

Cucumber, insects of (*See cantaloupe*) 40-46

Cutworms, life history, habits and remedies—*illustrated* 11

Egg plant, insects affecting...... 46, 47

Feeding habits of insects........... 8

Fertilizer, for root maggots......... 28

Flea-beetle, the cucumber—*illustrated* 44

Formulas for preparing spray mixtures—
  for biting insects............ 60-62
  for sucking insects.......... 63, 64

Fumigation for melon louse......... 41

Growth of insects................. 6, 7

Grubs, definition of.............. 7, 52

Grub worms, or white grubs—*illustrated* 52-54

Harlequin or terrapin bug—*illustrated* 18

Hellebore, use of.................. 62

Horn worm on tomatoes—*illustrated*, 59

Insects injurious to
  asparagus 9-11
  beans 11-16
  beets 16, 17
  cabbage, collard and cauliflower 17-29
  celery 30, 31

PAGE

Insects injurious to (*continued*)
  cantaloupes and cucumbers... 40-46
  egg plant 46, 47
  irish potatoes (*See potato*).. 49-54
  onion 47
  peas 47-49
  squash 54-58
  sweet corn (*See corn*)....... 31-40
  turnips (*See cabbage*)....... 17-29

Kerosene emulsion, preparation of... 63

Kerosene emulsion, use of, 18, 19, 22, 41, 55

Larva, definition of................ 8

Life history of insects, in general.. 6, 7

Lime, uses of................ 43, 60, 61

Maggots, definition of............ 7, 28
  affecting cabbage—*illustrated*... 28
  affecting onions 47

Melon plant lice—*illustrated*........ 40

Melon borer—*illustrated*............ 57

Nymph, definition of............... 8

Onion, insects of.................. 47

Parasites of cabbage aphis.......... 18

Parasites of melon aphis........... 42

Paris green, uses of............... 60

Pea weevils—*illustrated*............ 47

Pickle worm of cantaloupe, etc.—*illustrated* 44

Poisoned bait for cutworms......... 14

Potato (irish), insects of........ 49-54
  Colorado potato beetle—*illustrated* 49
  3-lined potato beetle............ 51
  flea-beetles on 51
  stalk borer—*illustrated* 51
  white grubs injurious to—*illustrated* 53

PAGE

Pupa, definition of................. 7

Pyrethrum, uses of................. 64

Red spider 31, 40

Resin wash and arsenicals.......... 62

Soap solutions, as insecticides....... 63

Spray mixtures, formulas......... 60-64

Spray pumps and equipment......... 64

Squash, insects of............... 54-58
  bug—*illustrated* 54
  melon borer on—*illustrated*..... 57
  vine borer—*illustrated* 55

Striped cucumber beetle—*illustrated*. 42

Sweet corn, insects of (*See corn*).. 31-40

Sucking insects 8

Sulphur, uses of.................. 31

Terrapin bug—*illustrated*........... 18

Tobacco, uses of............. 18, 43, 63
  dust as a repellent............. 63
  fumigating papers 64

Tomato, insects affecting........ 58, 59
  fruit worm 58
  horn worm—*illustrated* 59

Trap plants, uses of.......19, 22, 38, 43, 46, 55

Weevils in beans—*illustrated*....... 15
  corn—*illustrated* 39
  peas—*illustrated* 47

Whale oil soap, uses of............ 63

Webworm, the cabbage—*illustrated*.. 23

White grubs—*illustrated* 52

Wireworms—*illustrated* 31

SOME INSECT ENEMIES OF GARDEN CROPS

CONTAINING PRACTICAL INFORMATION CONCERNING THE HABITS AND LIFE HISTORIES OF CERTAIN INSECTS, WITH REMEDIAL SUGGESTIONS

By **R. I. SMITH**, Entomologist

Without the home garden the farm is incomplete. Even the town or city home with its small area of land should possess a garden in which many vegetables may be grown to help supply the table, and reduce the market and grocery bills during both summer and winter. It often happens that the pleasure and profit derivable from the possession of a garden are both greatly diminished by the insects that prey upon the various vegetables, and sometimes entirely destroy them. Far too many gardens are carefully prepared and planted and afterwards allowed to become food for various insects, mainly through ignorance on the part of the gardener of the methods by which they might be controlled. For the person who aims to sell a part of his garden products a knowledge of insects and their control is especially necessary. The question of profit or loss may depend on the suppression or non-suppression of these pests.

It is only too true that some insects are difficult or almost impossible to suppress, but the great majority are within man's control when the proper remedial and preventive measures are applied. An illustration of well known and fairly easily preventable insect injury, occurring annually, is that of the Colorado Potato Beetle, which is perhaps one of the most common. The writer has frequently met with farmers, and small garden owners, who relied solely upon hand picking for the suppression of potato beetles, and frequently even this unsatisfactory method was delayed until the plants were nearly destroyed. How much time, labor, and expense, to say nothing of actual loss, such people might have saved by dusting the potato plants with dry Paris-green mixture, or by using the same poison as a liquid spray. This method of fighting the potato beetle and similar simple, reliable remedies for other insects are discussed in subsequent pages.

Numerous illustrations are inserted to assist the reader in recognizing the insects mentioned and as an aid in understanding their life history and habits. Without some knowledge of these facts insects can not generally be fought intelligently.

In these pages no attempt has been made to include all the various insect enemies of the crops mentioned, but such only as may appear every year and cause more or less damage unless fought successfully. *"To be forewarned is to be forearmed,"* should be the maxim of every gardener. A knowledge of the life history and habits of insects aids one in adopting more successful preventive measures against these enemies.

LIFE HISTORY AND DEVELOPMENT OF INSECTS.

The habits of insects constitutes a very interesting and broad field for study and investigation. Without some knowledge of the development, i. e., the life history of our principal injurious insects, we would be poorly equipped to conduct a warfare against them. It is not to be expected, nor is it necessary, that every gardener should know all about the changes undergone by these interesting insects, but there are a few principles governing their growth and habits that every person may readily remember. One of these is the *development,* or the changes that an insect undergoes during its life, and another is the *feeding habits* of all the various forms. These two principles, it will be found, are closely related, for certain insects, while in the young, immature stage, secure food by biting and chewing, like caterpillars; while the adult or parent of the same insect may take its food in an entirely different manner, for example, moths and butterflies. Grasshoppers, on the other hand, *always* chew their food, and in order to illustrate two forms of Insect Development, we will compare their growth with that of the Green Cabbage Worm.

Incomplete Metamorphosis.—Grasshoppers undergo incomplete metamorphosis or *direct development,* as there are only three distinct stages of growth, namely, *Egg, Nymph* (young), and *Adult.* Grasshopper eggs are deposited in masses in the ground, and from them, in due time, minute grasshoppers hatch, resembling the adult in

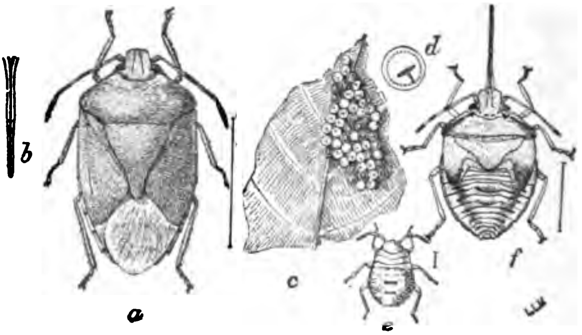


FIG. 1—Plant Bug, *Nezara hilaris:* *a*, mature bug; *c*, egg mass; *e*, young nymph; *f*, last stage of nymph—enlarged. (Chittenden, Farmers' Bul. 223, U. S. Dept. of Agr.)

general shape but somewhat clumsy in appearance and lacking wings. As they increase in size by successive molts, the wings commence to develop, first appearing as small, blunt pads, and finally becoming full grown. During this development the grasshopper always retains its general form and appearance. That is, a young grasshopper may always be recognized as such. Fig. 1 illustrates the similar growth of a plant bug *(Nezara hilaris)*, a sucking insect that sometimes punctures and injures cotton bolls.

Complete Metamorphosis.—Cabbage worms have a markedly different life history from the grasshopper, as they pass through four distinct stages, namely, *Egg, Larva* (worm), *Pupa* (quiescent stage) and *Adult.* This is called "complete metamorphosis" or *Indirect Development.* The adult or parent of the cabbage worm is a conspicuous white-winged butterfly (See p. 21.) that flies about collard and cabbage fields on any bright, warm day. These deposit eggs that hatch into minute worms, which, when grown, change to pupæ corresponding to the familiar cocoon stage of many butterflies and moths. From the pupæ the perfect, fully developed butterflies emerge. To one wholly ignorant of the growth of insects these wonderful changes might seem impossible, but the statement may easily be verified by any one caring to make the experiment. The four stages of the Bean-leaf beetle showing "complete metamorphosis" are illustrated in Fig. 6, p. 15.

A few common garden insects have direct development, the young resembling the adult, such as plant lice, terrapin bugs, squash bugs, plant bugs and grasshoppers, but by far the great majority of them have indirect development, passing from the worm, grub, or caterpillar stage, to entirely different looking forms, such as beetles, moths and butterflies. These complete changes in appearance have at times given people erroneous and ridiculous ideas about certain insects. As an example, the writer once received a letter from a farmer, stating that the plant lice had been very abundant on his cantaloupes, but that they were then changing to beetles. These proved to be lady-bird beetles, predaceous parasites feeding on the lice, and of course an entirely different kind of insect. Besides, the beetles were directly responsible for the disappearance of the injurious lice.

COMMON NAMES OF IMMATURE INSECTS.

Entomologists classify insects into various orders, and have adopted a few common, accepted names for the young or immature stage of certain orders. For example, *Maggots* develop into two-winged flies (Order: Diptera); *Grubs* into hard-winged beetles (Order: Coleoptera); *Caterpillars* (both smooth and hairy) into moths or butterflies (Order: Lepidoptera). These common titles are frequently made use of by writers. Thus the reader may understand that when white grubs are mentioned it refers to the young of some beetles, generally May or June beetles. Similarly when caterpillars are mentioned the term always refers, or should refer, to the larval stage of moths or butterflies.

The term *larva* (plural spelled larvæ) may be used in referring to the young stage of all insects that have complete metamorphosis, such as beetles, bees, flies, moths, etc. The word *nymph* is used for the young of grasshoppers, terrapin bugs, squash bugs, etc., that resemble the adult insects.

CHEWING AND SUCKING INSECTS.

More important in some respects than the knowledge of the life history of an insect, is that of its feeding habits. Every gardener should understand how insects get their food, whether by chewing or sucking, for without that knowledge he can not as readily understand why certain remedies are suggested against different insects. As already mentioned, the caterpillars, represented by cut-worms and cabbage worms, feed by chewing and actually devouring some portion of the host plant, while the parent moths or butterflies feed entirely differently. All beetles and their young feed by chewing. On the other hand, all plant lice, squash bugs, and most insects commonly known as "bugs," feed by means of long, slender beaks, which are used to pierce the plant tissue, and through which the plant juice is extracted.

Insects, therefore, may be divided into two great classes: first, *Chewing* or *Biting Insects*, and, second, *Sucking Insects*. The former includes all insects, whether in the immature or adult stage. that feed by biting and chewing; the latter includes a large class of insects that feed only by sucking the plant juices. A moment's thought will reveal the reason why it is that a poison spray, such as Paris-green mixture, that acts as an internal poison when swallowed with the food, would not kill an insect that sucks the sap. The latter make only a minute hole with the pointed beak and suck the sap from beneath the surface. How, then, may sucking insects be killed? Naturally by some substance that will kill by contact, having a corrosive, caustic, or suffocating effect. Kerosene emulsion, soap solutions, etc., are examples and are described more fully on pages 63 and 64.

This brief, simple statement of facts is inserted mainly as a suggestion to those readers who desire to learn something about insects. Of course arsenical poison sprays and contact sprays are useless against some insects. Borers and other forms that feed in protected places, even though they chew their food, can not be reached with arsenicals, neither can sucking insects be killed by a contact spray unless touched by the mixture. It is customary for people to think that all garden insects may be killed by a spray of some description, but this is an erroneous idea. White grubs in the soil feeding on the roots, boring insects hatching from eggs laid under the skin of plants, leaf-mining insects working between the two surfaces of a leaf, and others, can not readily be killed by any spray mixture. For these and various reasons it is necessary to understand the life history of insects; then the weakest, most vulnerable period in their career must be selected as the proper time to effect their eradication or suppression.

Nearly all insects succumb to poison fumes like carbon bi-sulphide and hydrocyanic acid gas, and insects in stored grains are best controlled by the fumigation method. With certain garden insects, cultural methods may be the only successful means of fighting them, and at times two or three methods may be combined against a single species.

INSECTS AFFECTING ASPARAGUS

Fortunately there are not many insects injurious to this valuable plant. There are, however, two asparagus beetles, both imported species, that may do considerable damage. Their injury is due to both adults and larvæ feeding on the young, tender, marketable shoots, rendering them unfit for sale, and also to defoliation of older plants. Since their habits and method of injury to asparagus are much the same they will be mentioned here together.

COMMON ASPARAGUS BEETLE (*Crioceris asparagi,* Linn.).
THE 12-SPOTTED ASPARAGUS BEETLE (*Crioceris 12-punctata,* Linn.).

DESCRIPTION AND LIFE HISTORY.

Beetles.—Are about one-fourth inch in length, both species being somewhat strikingly colored and marked. The common asparagus beetle, shown in Fig. 2, has the thorax or fore part of the body, reddish-yellow marked with two black spots. The wing covers are marked by a bluish-black stripe along the middle line where they meet, and lateral extensions of this main stripe extend toward the edges, which are orange colored. The intervening color is lemon-yellow. The underside of the body and the legs are usually shining black. The 12-spotted beetle is uniformly reddish in color, with twelve black spots on the wing covers (Fig 3). The body is broader than the common species. These beetles cause much damage by gnawing into the young marketable shoots, and later the beetles of the common species help to defoliate the plants, while the 12-spotted beetles feed mainly on the berries.

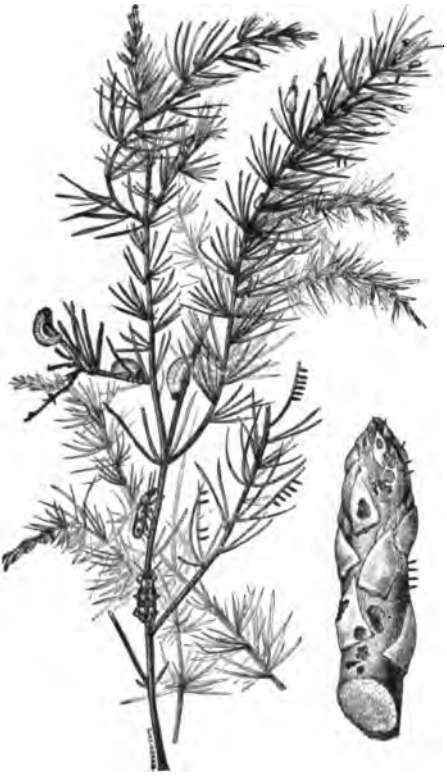


FIG. 2.—Common Asparagus Beetle on asparagus: Showing eggs, larvæ and adult; asparagus top at right, showing eggs and injury. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

Hibernation.—The beetles pass the winter hidden about in any convenient shelter, under loose bark of trees, in fence corners, and like places, coming forth in early spring as the asparagus commences growth.

Eggs and Egg-Laying.—The eggs of both beetles are similar in shape, but those of the common species are placed on end, usually in rows, while the others are laid singly and flat against the plant. While the beetles may appear at about the same time, the 12-spotted beetles do not often commence to deposit eggs until a month has elapsed, while the common species commence quite early.

Larvæ and Feeding Habits.—The larvæ of the common asparagus beetle when first hatched do much damage by gnawing into the tender shoots, and in this work they are assisted by the adult beetles. The larvæ, called *"grubs,"* may attain a size of one-fourth inch or slightly longer. They are soft bodied, yellowish or dark gray in color. The larval period varies, but is usually about twelve days, after which they drop to the ground, burrow down and change to pupæ in dirt-covered cocoons.

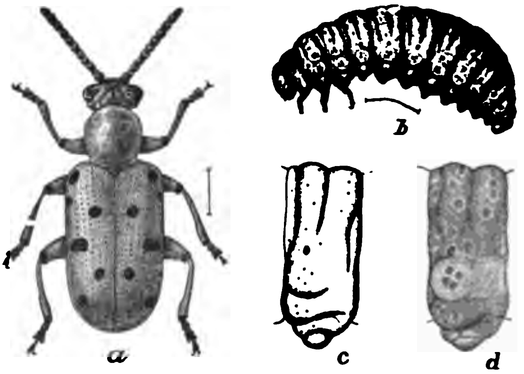


FIG. 3.—12-Spotted Asparagus Beetle: *a*, beetle; *b*, larva. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

As already stated, the eggs of the 12-spotted beetle are deposited late and the larvæ feed on the berries, if present, causing them to drop before ripening. In appearance these larvæ do not differ materially from the ones just described, except for being reddish in color.

Generations.—The life cycle from egg to adult requires only about thirty days, hence there may be several broods each season. The beetles hibernate quite early in the fall.

REMEDIES AND PREVENTION.

Asparagus beetles should be controlled by preventive measures largely, although direct remedies are at times necessary. Commencing early in spring when the beetles first appear, the asparagus grower should aim to destroy all eggs deposited, before they hatch, and supplement this by poisoning the beetles on trap plants. The eggs of the common asparagus beetle are frequently laid in the bud of young shoots just as they appear, or on the stems of any plants in the field. Obviously all old plants, with the exception of a few left as trap plants, should be cut down, and new shoots cut out clean at least every three days. Beetles and larvæ on trap plants may be shaken into a pan of kerosene, and the plants may be dusted frequently with a mixture of lime dust and Paris green, using one pound of the poison in thirty pounds of air slaked lime. The lime dust alone is an effective remedy for the soft bodied larvæ, killing all that it touches, and the mixture acts as a poison to both larvæ and beetles.

Trap plants bearing eggs and larvæ should be cut out frequently—at least once a week, and new plants allowed to grow up in their place. Since the larvæ of the 12-spotted beetle feed mainly in the berries they can not well be poisoned; hence frequent destruction of plants bearing the eggs is advisable. Larvæ of the common species may be shaken from the plants on sunny days when the earth is hot, and many will die before getting back to the plants.

Arsenate of lead (See p. 61), as a liquid poison spray, may be used on fields that are allowed to grow during summer and fall.

INSECTS AFFECTING BEANS.

Bean plants are subject to injury from leaf eating insects from the time they appear above ground; the fruit may be damaged by boring caterpillars; the stored beans partially destroyed by weevils; the seed when planted is sometimes injured by ants and wireworms, and young plants severed by cut worms.

WIREWORMS (See under Insects Affecting Corn, p. 31).

CUTWORMS *(Larvæ of Night Flying Moths).*

To gardeners these pestiferous creatures are very familiar. Some, however, may not be acquainted with their life history, or the best remedial measures. The former is very interesting and indicates how the larvæ should be fought. When beans, and many other garden plants commence to appear in spring, they are cut off at night just above the surface of the soil by these pests. During the day the cutworms lie in shallow burrows in the soil or under any available cover, coming forth to feed only at night. There are a number of species, variously known as greasy, variegated, dark-sided, glassy, clandestine, etc., all having about the same habits, but differing in appearance.

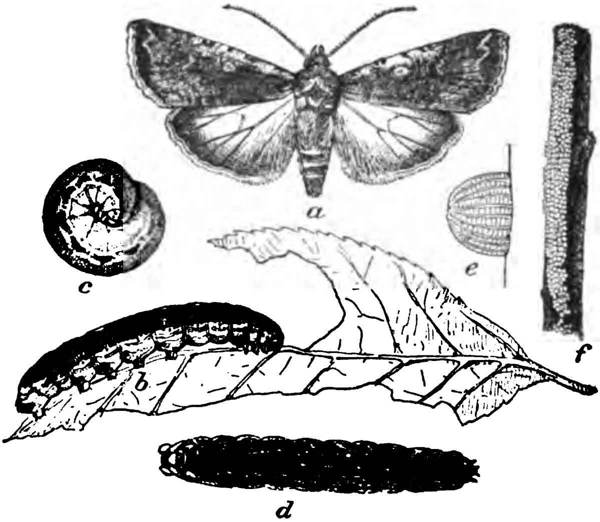


FIG. 4.—Variegated Cutworm, ***Peridromia saucia:*** ***a***, adult moth; ***b***, ***c***, and ***d***, larvæ (3 views); ***e***, single egg much enlarged; ***f***, egg mass on grass stalk. (Howard, Div. of Ento., U. S. Dept. of Agr.)

DESCRIPTION AND LIFE HISTORY.

Life History.—Noticeable damage by cutworms occurs mainly in spring when gardens are first started. The worms responsible for the damage are ones that pass the winter in hibernation, awaiting the advent of spring to issue forth in search of food. To appreciate the appetite displayed by cutworms one must understand their life history, which is as follows:

About June or July cutworms become fully grown. They then burrow into the earth, form silk-lined oval cocoons and transform therein to pupæ. About three weeks later the adult parent moths emerge and soon deposit eggs for the next brood. The eggs (Fig. 4, f) are placed on any succulent vegetation, grass or weeds, on which the larvæ, when hatched, feed and become about one-half grown before winter weather drives them into hibernation. The following

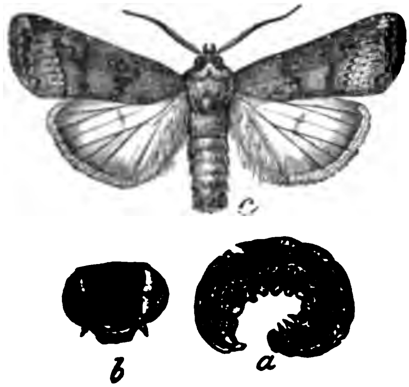


Fig. 5.—Black Cutworm, *Agrotis ypsilon*: Showing larva and adult moth. (Riley and Howard, Div. of Ent., U. S. Dept. of Agr.)

spring they awake with ravenous appetites after their long winter's fast, and naturally devour any green vegetation at hand.

Parent Moths.—The moths shown in Figs. 4 and 5 are of medium size and have wings, which expand one and one-half to two inches. The front wings are dark brown or gray, never conspicuous, but usually bearing a kidney-shaped spot of lighter color; hind wings always lighter than the fore wings. These moths hide during the day, but if disturbed fly with a quick, darting motion.

Larvæ.—All have naked bodies, varying in color from dirty green to gray and brown, but often distinctly marked with longitudinal dark stripes and dots. They have three pairs of true legs at the anterior (head) end and five pairs of fleshy pro-legs behind (Fig. 4, b). When disturbed they always curl up, as shown at Fig. 4, c.

Generations.—Only one generation occurs each year, and the greater portion of their life is passed in the larval stage.

REMEDIES AND PREVENTION.

Preventive measures are preferable to direct remedies, though the latter are fairly successful. Gardens that are in constant cultivation and that are kept free from weeds would not be greatly infested with cutworms, were it not for the ones that wander in from adjoining grass lands, but as this always occurs gardens are seldom exempt from them. The natural food of cutworms is grass, and for this reason sod land during the first year's cultivation is liable to be badly infested.

Cultural Methods.—Gardeners may determine with reasonable certainty what fields are most liable to be infected. Sod land, or grassy and weedy gardens may always be suspected. Such lands should be plowed deeply in fall or early winter to disturb the cutworms in their earthen hibernating cells. Some will be exposed as prey to fowls and birds and some may die from exposure to the winter weather. It has been stated also that the rains soaking into the loosely plowed land will drive some larvæ from their cells. Cross plowing to further disturb and expose the cutworms is certainly advisable.

Domestic fowls should be encouraged to follow the plows, as they will destroy great numbers of insects.

Paper Bands.—In small gardens, plants like tomatoes, cabbages, egg-plants, etc., may be protected from cutworms by bands of stiff cardboard or tarred paper pressed into the soil surrounding the plants. They need not be over one and one-half inches above the soil, as cutworms seldom climb. Occasionally a species of climbing cutworm appears, which must be fought by poison sprays or poisoned bait. Vertical holes with smooth, hard sides made close by the plants, are said to be good traps, as the cutworms crawl into them, and are unable to get out.

Poisoned Bait.—This is no doubt the best remedy to be used against cutworms before the crops are planted, acting as a preventive measure, though it may be used later. To make the best use of poison bait, prepare the garden or field by raking off all vegetation a few days before the crop is planted or seeds come up. Leave the land a few days, which will result in making the cutworms hungry. Then apply a bait made as follows: With forty pounds of corn-meal mix one pound of Paris green or white arsenic; moisten with water to make a rather stiff mash, and sweeten with two quarts of common molasses. Apply this bait about sundown in little heaps at frequent intervals over the field. Repeat this application for two or three nights in succession. In this way, many cutworms will be poisoned, especially if the land is free from vegetation. The bait may be placed in heaps close by plants that should be protected, but the paper bands are more effective.

Another good poison bait is made by cutting some succulent clover and dipping it in a barrel of water containing one pound of Paris green. This may be used while fresh the same way as the corn-meal bait.

All poisoned baits must be used with caution, or not at all, if chickens are liable to get to it.

BEAN LEAF BEETLE (*Cerotoma trifurcata,* Forst).

Injury is caused by the adults eating round holes in the leaves of beans and cowpeas, while the larvæ feed on the roots or main stem just below the surface of the soil.

DESCRIPTION AND HABITS.

The beetles are about one-sixth inch in length, varying in color from yellowish to reddish with black marking as shown in Fig. 6. When abundant, the beetles may defoliate plants severely. They hibernate during winter and usually appear quite early in spring.

The larvæ are slender in form and whitish in color, and feed on the roots or stems in the manner stated above.

There may be two or three generations. According to Chittenden[1] the life cycle requires from six to nine weeks.

---

[1] Yearbook Dept. of Agr. 1898, p. 254.

REMEDIES.

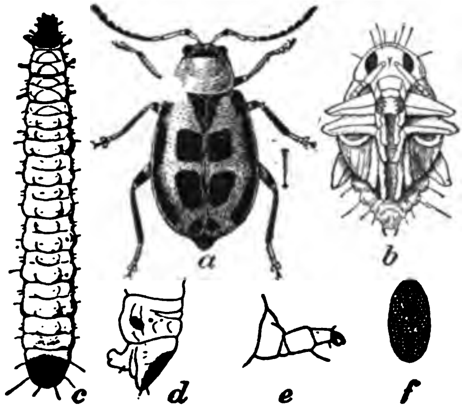


FIG. 6.—Bean Leaf-Beetle: *a*, adult beetle; *b*, pupa; *c*, larva; *f*, egg—*a*, *b*, *c* enlarged about six times, *f*, more enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

Spraying the plants with an arsenical poison, Paris green or arsenate of lead preferably mixed with Bordeaux mixture (See p. 61), is undoubtedly the best remedy. When the early appearing beetles are poisoned later spraying should not be necessary. String beans should not be poisoned when the pods are maturing. Further preventive measures against similar leaf-eating beetles are discussed on page 43 under cucumber beetles.

COMMON BEAN WEEVIL (*Bruchus obtectus*, Say).

The common bean weevil, *Bruchus obtectus*, Fig. 7, as well as other species of *Bruchus*, annually infest quantities of dried beans, rendering them unfit for food or seed. Infested beans are readily detected, upon examination, as every housekeeper could testify. Many people believe that beans become infested *only* after they are stored, and such may at times be true, but a large proportion are first infested in the field or garden.

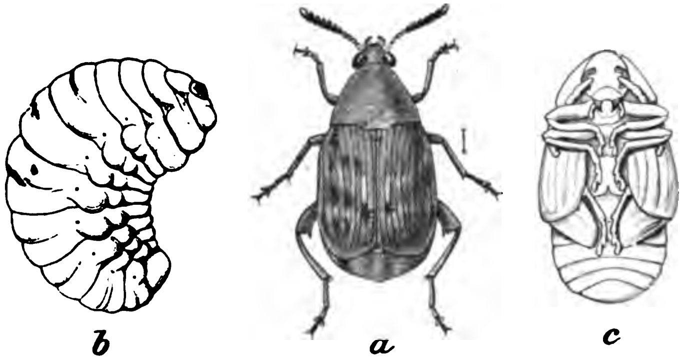


FIG. 7.—Common Bean Weevil, *Bruchus obtectus*: *a*, beetle; *b*, larva; *c*, pupa—all greatly enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

LIFE HISTORY AND HABITS.

Dried stored beans once infested with weevils may continue to become worse infested by successive generations. If not disturbed the weevils may produce five or six generations each year and single beans may contain a number of weevil larvæ at one time.

Ordinarily, beans first become infested in the field, the weevils depositing eggs through slits or cracks in the green pods, and the larvæ, as soon as formed, bore into the beans. Their presence is indicated only by a small black speck on the skin. In dried beans, the weevils are readily detected because they eat away all but a very thin layer of outer skin.

The adult bean weevil *B. obtectus,* is about one-sixth inch in length, grayish brown in color, and has the end of the abdomen extending beyond the wing covers. Other species of bean weevils differ in size and coloration, but all may be distinguished by the short wing covers. Fig. 8 represents the four spotted bean weevil, *B. 4-maculata.*

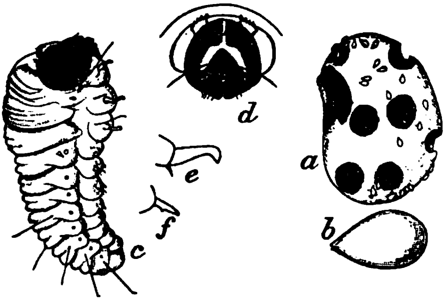


FIG. 8.—The 4-Spotted Bean Weevil, *Bruchus 4-maculata:* Showing cowpea (*a*) with holes made by weevils, and also eggs on the surface; c, embryonic larva. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

REMEDIES.

There is no way of preventing infestation of beans in the field if the parent beetles are present. To prevent their being present stored beans, peas and cowpeas should be thoroughly fumigated during fall and winter, so that no adult beetles may escape. The method of fumigation is fully described under pea weevils, p. 48. (See also corn weevils, p. 39.)

INSECTS AFFECTING BEETS.

CUTWORMS (See under Bean Insects, p. 11).
FLEA BEETLES (See under Cucumber Insects, p. 44).
WEB WORM (See under Cabbage Webworm, p. 23).
WIREWORMS (See under Corn Insects, p. 31).

BEET LEAF-MINER *(Pegomyia vicina,* Lint.).

This insect may not occur in North Carolina, but if not this particular species, some similar ones do occur. The beet leaf-miner is common in States where the sugar beet is grown and may cause considerable injury. Many garden plants are injured more or less by leaf-mining insects, hence the brief account here given of the beet leaf-miner should be of general interest.

Beets and other plants are often found with raised or blistered blotches, or channels in the leaves, these areas eventually turning brown and dying, rendering them unfit for greens. The cause of this damage is a small larva or maggot feeding between the two surfaces of the leaf.

The adult of the species mentioned above is a two-winged fly, resembling the common house fly, only smaller. The eggs deposited by these flies hatch into minute maggots, that bore at once into the leaves. When grown the maggots usually leave their channels to pupate.

PREVENTIVE MEASURES.

As sprays are useless to poison the larvæ, the gardener's recourse is to destroy the infested leaves. When beets, turnips, etc., are used for greens, all discarded leaves should be burned rather than left in the fields. The insects pass the winter in the pupæ stage under leaves and rubbish, and may be destroyed by clean cultural methods.

INSECTS AFFECTING CABBAGE, COLLARD AND CAULIFLOWER.

A long list of insects are known to attack these and closely related crops, and since no garden operation is complete without these valuable plants, their insect enemies should be well understood.

Cutworms.—(See under Bean Insects, p. 11).

Flea-Beetles.—Poison applications used against cabbage worms, p. 22, should also control the flea-beetles. The reader should refer also to control of flea-beetles on cucumbers, etc., p. 44.

Cabbage Aphis *(Aphis brassicæ,* Linn.).

Green lice on cabbage, collards, and related crops, familiar to all gardeners, may appear early in the spring, but are generally most abundant and destructive in late summer and fall. Particularly is this true in fall after cool weather commences, and is due mainly to the fact that natural parasitic enemies are able to keep the lice reduced to small numbers during warm weather.

LIFE HISTORY AND FEEDING HABITS.

Cabbage aphis, like all plant lice, feed by piercing the plant tissue with their long, slender beaks and sucking the plant juices. When numerous they may cause plants to wither and die, and only small numbers may serve to stunt the growth. These lice multiply very rapidly, the young being born alive by both winged and wingless viviparous females. The winged females serve to spread the colonies, that is, a single winged individual may fly to an uninfested plant and start a new colony. No true males and females are present during the summer months, but are developed by the last brood. A winged male is shown in Fig. 9, a. The true females develop eggs that serve to carry the species through the winter. Colonies of cabbage lice are usually more or less covered with a white powder, which they secrete, and great numbers of molted skins are always present.

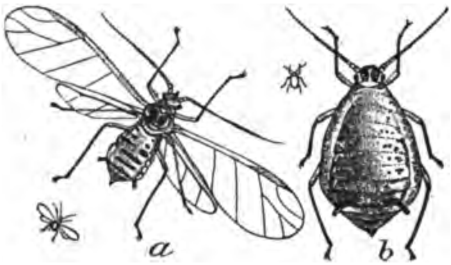


FIG. 9.—Cabbage Louse: *a*, winged male; *b*, wingless female—much enlarged.

PARASITES.

Were it not for the number and activity of parasites attacking the cabbage aphis, this would be a very serious pest. Predaceous parasites, such as lady-bird beetles and their larvæ, and aphis lions, together with internal parasites belonging to the Hymenopterous insects, usually serve to keep the aphis down to comparatively small numbers during warm, dry weather in summer. Later, the lice become more numerous, mainly because their parasites are not so active or else they stop work entirely because of the cold weather.

REMEDIES.

Soap Solution.—For all lice, as previously stated, contact sprays of sufficient strength are effective. It is surprising how easy the cabbage lice may be killed with soap solution, which acts by suffocation and caustic effect. Ordinary strong potash washing soap, or powder, will do the work. Dissolve one pound in about four gallons of water and apply to infested plants with considerable force and in liberal quantities. The lice are often so thickly massed together that those underneath will escape unless the solution is applied as a fine spray and with *force*. A spray pump is quite necessary and should be provided with a short hose and extension rod with a curved end, in order to throw the spray on the under sides of the leaves. Failing in this, the leaves must be turned over and the colonies of lice saturated with the solution. *Simply sprinkling the tops of infested plants does very little good.*

Other Contact Sprays.—Kerosene emulsion of 10 part concentration, tobacco decoction, pyrethrum powder and whale oil soap (See p. 63 for direction for preparing) are all good remedies, but not superior to common soap solution when properly applied.

TERRAPIN OR HARLEQUIN BUG (*Murgantia histrionica,* Hahn.).

This gayly colored plant bug, so common and destructive, is another sucking insect, feeding on the plant juices. Its attack is more serious than the plant lice because, in addition to sucking the sap, it injects into the plant tissue a poison that causes the foliage to turn brown, shrivel and die. A very few terrapin bugs may kill young plants. They attack all cruciferous crops.

DESCRIPTION AND HABITS.

Adult Bugs.—The fully grown bugs are about three-eighths inch in length, and one-fourth inch wide. The head is short, with the long beak springing from beneath and lying between the legs when not in use. The body presents a blunt, broad-shouldered appearance. The general color is black with orange or yellow markings. (See Fig. 10.)

The adults live in hibernation during winter in any protected place.

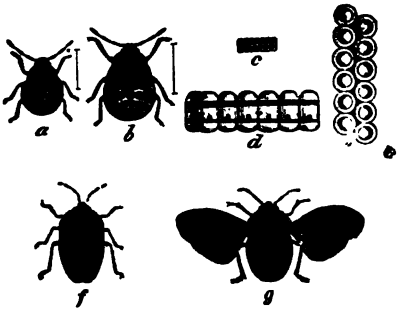


FIG. 10.—Terrapin Bug: *a* and *b*, nymphs; *c*, eggs; *d*, eggs enlarged; *f* and *g*, adult bugs.

Eggs.—Are usually laid on the under sides of the leaves in double rows of twelve, as shown in Fig. 10, e. Each egg appears barrel-shaped and is marked by black bands, Fig. 10, d.

Nymphs.—The young, called nymphs, resemble the adults except that they are smaller and lack wings. In this stage they have comparatively soft bodies and succumb to strong contact sprays.

REMEDIES AND PREVENTION.

Old fields of collards and similar crops are veritable feeding grounds for terrapin bugs. By thorough cleaning up of such fields in fall much trouble may frequently be averted. Strict cleaning up and burning of all stray plants and rubbish about gardens and fence corners during winter will destroy many hibernating adults.

Trap Plants.—The adult bugs, first appearing in spring, seem to be partial to mustard, radish and rutabaga plants, and these may be planted early and used as trap plants. Only a few are necessary. The bugs that gather on such plants may be collected by hand or shaken into a pan containing a little kerosene, and when eggs are deposited and nymphs appear they may be killed by spraying with 15 per cent kerosene emulsion, or with pure kerosene, but the latter will kill the plants. When the trap plants become too badly infested, they may be pulled and burned. Persistent warfare in early spring should so reduce the number of bugs as to protect the later crops.

Kerosene Emulsion.—When used liberally of 15 per cent concentration (See p. 63) this will kill all the young and nearly mature nymphs that it comes in contact with and will kill some adult bugs. Before the wings are developed, the bugs are not so difficult to kill. Two or three such sprayings at intervals of five or six days should nearly exterminate the bugs, even on badly infested crops.

When spraying with emulsion, many bugs drop from the plants to the ground, and should be thoroughly saturated where they lie, and this is quite important, as very few will live to return to the plants. Kerosene emulsion must be properly prepared, so that the oil does not readily separate, otherwise the plants may be injured by the spray.

CABBAGE WORMS.

No less than five distinct species of leaf-eating worms are annually present, and are quite injurious to cabbage, collard, turnip and related plants. One species, the cabbage web worm, has never before been reported as occurring in North Carolina. In addition to the five different worms mentioned below, cabbage and related crops may at times be attacked by the larvæ of the Southern cabbage moth, zebra caterpillar, army worm, corn worm, yellow woolly bear, and possibly other minor leaf-eating pests. The following, however, are the only ones that the gardener need fear:

IMPORTED CABBAGE WORM *(Pontia rapæ,* Linn.).

As the name implies, this destructive pest was introduced into this country from Europe, first appearing in the United States about 1865. It is now prevalent throughout North America and Europe. Although an introduced pest it has far outstripped in numbers the native cabbage worm, described further on.

DESCRIPTION AND HABITS.

Parent Butterfly.—The parent of the imported cabbage worm is a white-winged, active, day-flying butterfly. The majority of the white butterflies that hover about cabbage and collard fields on bright, sunny days are the adults of this species.

The female butterflies have white wings expanding about one and three-fourths inches, the front wings having a black spot at the tip and two black dots near the center, while the hind wings have only one black dot near the front margin (Fig. 11). The males differ in having only one black dot on the forewings, but otherwise closely resembling the females. The butterflies deposit eggs on all cruciferous crops, but particularly on collard, cabbage, and cauliflower.

Eggs.—These are laid on the under sides of the leaves; they are oval in shape, white at first, but soon assume a yellow color, and hatch

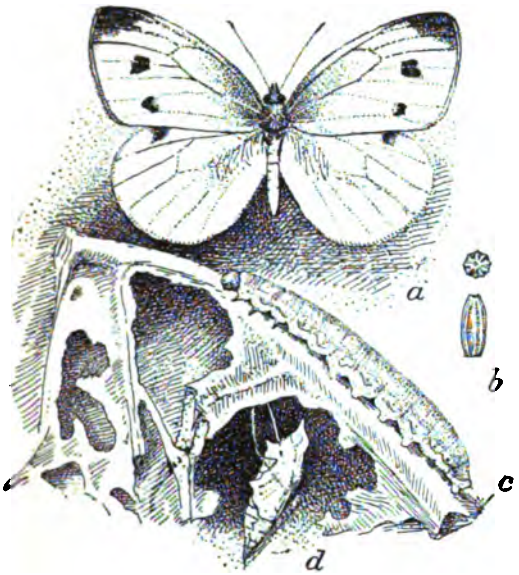


FIG. 11.—Imported Cabbage Worm: *a*, female butterfly; *b*, egg—much enlarged. *c*, larva in natural position; *d*, pupa suspended; (Chittenden, Cir. 60, Bur. of Ent., U. S. Dept. of Agr.)

in four to eight days. They may be easily located on the plants by watching the female butterfly as she deposits them one at a time.

Larvæ.—The larvæ or young worms feed on the lower surface of the leaves, or in the opening bud, and rapidly increase in size, attaining full growth in about two weeks. They then appear green in color, one and one-fourth inches long, with a pale yellow stripe along the middle of the back. The body is clothed in short hairs, giving it a velvety green appearance. They move slowly without lifting the body, which they are enabled to do by possessing eight pairs of legs. This species seems to prefer to feed on the central leaves.

Pupæ.—The grown larvæ change to naked pupæ suspended to the underside of a leaf by a silken cord about the body and the tip of the abdomen attached to a mat of silk. Fig. 11, d, represents a pupa suspended, but not in its natural condition. The pupæ are irregular in shape, light green, and inactive except for being able to wriggle the abdomen when disturbed.

LIFE HISTORY.

Pupæ, also known as chrysalides, of the last fall brood, live through the winter. In the spring they transform into butterflies, which soon commence to deposit eggs. In warm weather the entire life cycle from egg to butterfly is completed in about thirty days, or less, so that five or six broods may develop during the year in the South. There are three broods in the New England States.

This, we see, is an insect having four distinct stages of development as already described, and naturally the larval or feeding stage is the time when it may be destroyed most readily, although adults may be caught in nets, and pupæ sought for and destroyed.

REMEDIES.

Poison Sprays.—A prejudice seems to exist against the use of poison sprays on cabbage, collard, etc., but it is largely without foundation. Garman, Entomologist of Kentucky, has made exhaustive experiments with Paris green mixture and found that it may be used safely if reasonable care be exercised in its application. Certainly the arsenical sprays are more effective against the worms than most other remedies on young and half grown plants. Garman sprayed cabbages four times with Paris green mixture, using as much as one pound of Paris green in one hundred gallons of water, and about two weeks after the last application he had entire cabbage heads, outer leaves and all, subjected to chemical analysis. Only a slight trace of poison could be detected; not enough to poison a person under any conditions. As cabbages grow from the inside outward, and the outer leaves are always removed before cooking, the writer does not hesitate to recommend the use of arsenical sprays until within three or four weeks of the time when such plants will be eaten. Cruciferous plants grown for greens alone may be poisoned also, using the same precaution. Resin-lime mixture, or Paris green-lime mixture, as recommended under formulas, page 62, will suffice to keep this and other cabbage worms in control. Four annual sprayings are usually sufficient.

Fresh hellebore acts as a poison both by contact and internally. It may be dusted on infested plants every two or three days, or used as a liquid spray.

Contact Sprays.—Cabbage worms, being soft-bodied and breathing through pores in the body, will succumb to contact sprays such as ten per cent kerosene emulsion, strong soap solution, or by dusting with common ar-slaked lime or ashes. Hand picking of worms from small areas is often advisable.

Preventive Measures and Trap Crops.—All remnants of cruciferous plants should be removed from the gardens and fed to stock or burned as soon as the crop is gathered, especially during late fall and winter, for the destruction of such plants will destroy many overwintering pupæ of the imported cabbage worm, and also those of nearly all injurious cabbage worms. Trap plants may be left in the field in fall to attract the butterflies to deposit eggs, but these should be freely poisoned and destroyed entirely before spring.

Parasites.—Several parasitic enemies assist in keeping the imported cabbage worm in control.

NATIVE CABBAGE WORM *(Pontia protodice,* Bd.).

Unlike the cabbage worm just described this is a native North American species, and is said to be more abundant in the South than in the North. Near Raleigh during October, 1907, no worms of this species could be found, but earlier in the season they were probably numerous. Doubtless the parasites got very active and nearly exterminated this species in this section last fall.

DESCRIPTION AND LIFE HISTORY.

The adult male butterflies resemble the imported species, already described, in size and color, but differ in having four angular spots on the front wings and small black marks near the tip, while the hind wings are not marked. The females differ very greatly in having both pairs of wings liberally checkered with angular black spots.

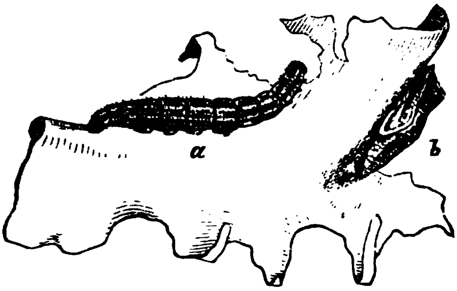


FIG. 12.—Native Cabbage Worm: *a*, larva; *b*, pupa. (Yearbook, 1888, U. S. Dept. of Agr.)

The eggs are laid singly on the undersides of the leaves.

The larvæ (worms) are greenish or purple in color and differ from the preceding form by having four longitudinal pale yellow stripes along the back. The head and body are dotted with black. The pupæ resemble those of the imported species and are similarly attached to the leaves (Fig. 12).

The life history of this species is practically the same as that of the imported cabbage worm.

REMEDIES.

The remedy is the same as for the imported species and one can not well be controlled without destroying the other.

Parasites.—Several beneficial parasites attack the native cabbage worm, often rendering other remedial measures unnecessary.

CABBAGE WEBWORM *(Hellula undalis,* Fab.).

Another imported pest of cruciferous crops is the webworm, a most injurious species, new to North Carolina, and of a comparatively recent occurrence in North America. The writer first discovered this pest quite abundant on turnips at West Raleigh in October, 1907, and it appears never to have been discovered previously in any part of this State. The webworm had of course been here all through 1907 and probably one or two years before, but without being detected.

HISTORY OF THE CABBAGE WEBWORM.

This insect was discovered in injurious numbers near Augusta, Ga., in 1898, but had been observed there the previous year. In Richmond County, Ga., in 1898, the damage caused by webworms to turnips, cabbage, beets, etc., was estimated conservatively at $20,000, and by some persons as high as $50,000. This serious outbreak led to an investigation by the Bureau of Entomology, Washington, D. C., which brought out the fact that the same insect had appeared near Charleston, S. C., in 1895, considerable damage in that vicinity being reported also in 1896. Three years later, in 1899, injury from webworms was reported from Auburn, Ala., and Athens, Ga., but the damage near Augusta, Ga., was not nearly so great as it had been in the year 1898.

From the information available it is thought that the cabbage webworm was first introduced near Charleston, S. C., and spread from there to Augusta, Ga. Now that it has been found at West Raleigh there is every reason to believe that in many places in North Carolina it already has a good foothold. Therefore our farmers and gardeners should study the following description and learn to recognize the pest.

INJURY CAUSED BY WEBWORMS.

The worms seem to prefer feeding in the bud of young plants or on the undersides of the leaves, or in the crown of plants like turnips and beets. On turnips, they may burrow into the crown, making shallow channels, and also eat off the leaves at their bases. The worms cover themselves with a web, probably remaining under it most of the time, though they may leave it at night to feed. When grown the worms spin silken cocoons, which are usually imbedded in a mass of web. Young plants are prevented from growing by the worms eating the bud, and older plants may be ruined in a few days if the worms are abundant. The presence of webworms is indicated by webs between the bases of the leaves of cabbage, collard, etc., and in the crown of beets and turnips. The worms may usually be found under the webs.

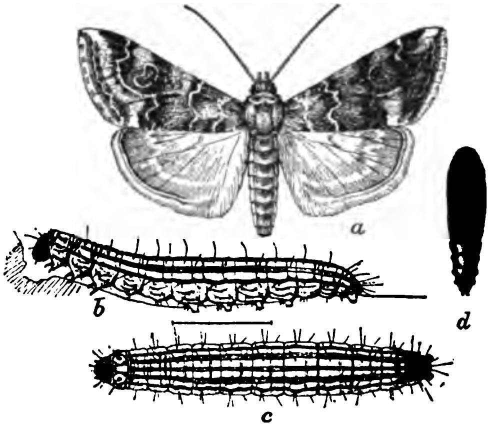


FIG. 13.—Cabbage Webworm: *a*, parent moth; *b*, and *c*, larvæ; *d*, pupa—all 3 times natural size. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

DESCRIPTION AND HABITS.

Eggs.—Eggs are laid singly or in masses, according to Chittenden,[1] and are at first white, changing to pink; the shape is oval, size small, but discernible to the naked eye; they hatch in three to four days.

Larvæ.—Full grown webworms are quite distinctive in appearance. They measure a little over one-half inch; color yellowish gray, marked above by five noticeable brownish stripes (Fig. 13, b, c); body dotted by a few yellowish or brownish hairs. The larvæ have eight pair of legs, three pair true legs in front and five pair pro-legs behind.

Pupæ.—These are not readily found because of being enclosed in tough silken cocoons spun between the leaves or in the crown of turnips and beets. The pupæ are shiny yellowish brown in color, and are about three-tenths of an inch in length (Fig. 13, d). As they pass the winter in this stage an excellent opportunity is presented to reduce their numbers by clean cultural methods.

Parent Moths.—In general shape and markings the moth is well shown in Fig. 13, a, much enlarged. The true size is about three-fourths inch when wings are expanded, but when resting with wings folded over the body they appear much smaller. The fore-wings are gray, marked with both darker and lighter stripes and spots. Hind wings are lighter in color. The moths fly and deposit eggs at night, and hide during the day.

Generations.—No definite information concerning the number of annual broods for North Carolina is available. We do not know how early the webworms become abundant, nor much about their life history. On this point, and many others, the writer hopes to get definite information this coming summer by field and laboratory observations. The life cycle as determined by Chittenden is about 27 days, but will, no doubt, be found to vary.

REMEDIES.

Arsenical Poisons.—Poisons if effective must be applied early, for when the protecting webs have been spun, poison sprays will not be of value. If the worms are detected when they first appear, some of them, and especially succeeding broods of larvæ may be poisoned. In other words, a poison spray applied thoroughly so as to penetrate well in between the bases of the leaves where the webworms commence to feed will kill many of the young. For this spray, it would be best to use Paris green, at a strength of 1 pound to 125 gallons of water with lime (See p. 60) or arsenate of lead at the usual strength. Dry dust poison applications may answer the same purpose if applied with a good powder dust gun that will throw the mixture forcibly into all crevices. As soon as the first worms appear apply poison liberally.

---

[1] **Bureau of Ent. Bul., 23, p. 59.**

Trap Crops.—Webworms seem to prefer cabbage and turnips, hence it would seem that these might be planted early and thoroughly poisoned to destroy the early broods. This would be a great protection to later crops of similar and related plants.

Clean Culture.—Webworms may undoubtedly be prevented from increasing in numbers by carefully burning or feeding, if suitable, all remnants of infested plants during fall and winter. When early crops are infested burn or feed the plants when the crop is gathered. Such practice is advisable against other cabbage worms that pupate on the plants and winter in that condition.

CABBAGE LOOPER *(Autographa brassicæ,* Riley).

This is probably the most injurious cabbage worm in North Carolina. Cabbages, collards, and rutabaga turnips are often almost stripped of their outer leaves, and the worms may bore into the cabbage heads. They move by a looping motion, rendering them easily recognized from the other common cabbage worms.

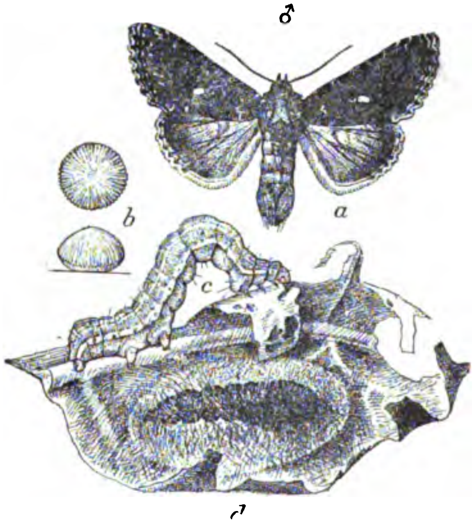


FIG. 14.—Cabbage Looper (*A. brassicæ*): *a*, male moth; *b*, egg (two views); *c*, larva in natural position; *d*. pupa under thin cocoon—*a*, *c*, *d*, slightly enlarged; *b*, more enlarged. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

DESCRIPTION AND HABITS.

Eggs.—Are small, pale green, round and flattened on one side with convex side up, and are deposited singly or in small clusters by the female moths about sundown or at night.

Larvæ.—When full grown they are one and one-half inches, or more, in length, pale green, marked with four fairly distinct stripes along the back. Less distinct longitudinal lines also occur. The body is smallest at the anterior end and bears three pairs of true legs on the first three segments, and three pair of pro-legs near the caudal end, one pair being on the last body segment (Fig 14, c.).

Because of not having pro-legs in the middle of the body these caterpillars move with a semi-looping motion, much like the familiar "inch or measuring worm."

Pupæ and Cocoons. The larvæ change to pupæ under thin silken webs on the under sides of the leaves, as shown in Fig. 14, d. The pupæ are about one-half inch long, shiny brownish in color, and may be seen through the thin webs.

Parent Moths.—From the pupæ, moths as shown at Fig. 14, a emerge to lay eggs for the succeeding brood. The moths have a wing-expanse of nearly one and one-half inches; fore-wings grayish brown and marked by a silvery dot and loop near the center; hind wings are lighter. They fly at night or about sundown, and hence escape observation.

Generations and Winter Stage.—Several generations occur each year and are checked only by cold weather. The last brood passes the winter as pupæ, which shows that fall and winter destruction of old infested plants should be practiced.

REMEDIES.

All remedial measures, trap plants, clean culture, etc., suggested above to be used against the imported cabbage worm, should be employed against this species.

DIAMOND BACK MOTH OR CABBAGE PLUTELLA *(Plutella maculipennis,* Curtis).

Although a small worm, this species may cause considerable damage by feeding on the undersides of the leaves and producing small, round holes. They do not often cut through to the upper surface. The larvæ much resemble the young imported cabbage worms, but may be distinguished from them by being extremely active if disturbed.

The parent moths are only about one-fourth inch in length and are seldom seen. They lay minute whitish eggs, which hatch within a few days. The larvæ are a little over one-fourth inch in length, of a pale green color, and when grown encase themselves in white cocoons, which are attached to the leaves. There may be several broods during each season.

REMEDIES.

Poison Spray, as previously recommended, is effective, and Garman states that tar-water has been found very effective in European countries. The winter is passed in the pupa stage, hence clean culture is most advisable.

CABBAGE ROOT MAGGOT *(Pegomyia brassicæ,* Bouché).

Small, white footless maggots sometimes infest the roots and base of cabbages and radishes and other related crops. There are probably two or three species of cabbage maggots in North Carolina, but a description of the one mentioned above will serve to give the gardener or trucker an idea of these pests and their habits.

DESCRIPTION AND LIFE HISTORY.[1]

Maggots are the young or larvæ of two-winged flies (Fig. 15). This species somewhat resembles the common house fly, only they are much smaller. They pass the winter as adults or pupæ, the latter remaining close to the roots of the plants on which the maggots subsisted. The flies appear in spring at about the time young cabbage plants are set out, and lay eggs on their stems or on the soil close by. The maggots feed on the outer roots, or stems when the latter is not too tough and hard.

The presence of maggots is indicated by wilting and drooping leaves, and a general weakened appearance of the plants. It is said that plants infested when young will surely die, unless some good remedial measure is applied.

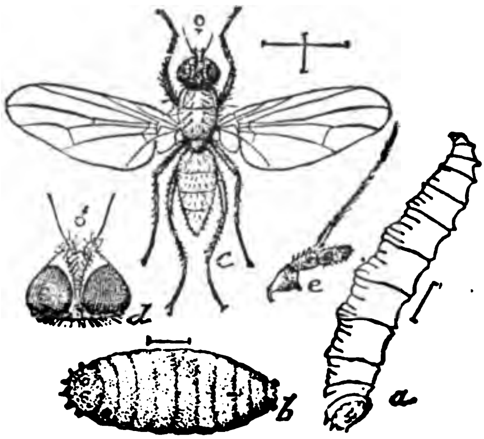


FIG. 15.—Cabbage Maggot: *a*, larva; *b*, pupa; *c*, adult. (Riley).

REMEDIES AND PREVENTION.

Tobacco dust applied liberally about the plants when first set out is of some benefit as a repellent.

Carbolic acid emulsion as recommended against the onion maggot, p. 47, may be used as a repellent.

Quick Acting Fertilizer.—Concerning the use of fertilizers Dr. Smith says: "A combination recommended consists of:

Nitrate of Soda	700 lbs.
Acid Phosphate	1,000 lbs.
Muriate of Potash	300 lbs.

---

[1] N. J. Sta. Bul., 200.

"The practice of plowing away from onion rows when infestation was noted and applying the above combination, or even nitrate of soda alone, has been followed with good results in Cumberland County, but has failed on heavier soils where the fertilizer did not get so quickly through the soil, and into direct contact with the plants and maggots. Both the nitrate of soda and the muriate have insecticidal qualities, but the acid phosphate has none. Manure and organic fertilizers should be avoided, if possible, as the group of insects to which these root maggots belong are naturally feeders in decaying matter, and hence such conditions tend to invite them."

Prevention.—Pull up and burn or otherwise completely destroy all stumps of plants, of whatever crop may have been attacked by maggots. Practice rotation of crops, for the parent insects do not fly very far. The cabbage maggot will breed in wild cruciferous plants, including some common weeds, such as mustard, hence all such should be destroyed. A good precaution when setting cabbage, or similar plants, is to press the soil firmly about the stem, as it will help to retard the maggots, when hatched, from getting down to the soft roots.

Planting an excess of seed when drilled in rows may insure getting a stand even where a large number of plants are attacked by maggots. The plants that become infested should be pulled out and destroyed. The reader should refer also to p. 47 concerning treatment for the onion maggot.

CABBAGE SNAKE (*Mermis albicans,* Diesing).

During recent years much excitement has been caused by the discovery of slender, white worms in cabbage heads, known as "cabbage snakes," and which have been reported as being deadly poison. How such accounts have originated it is hard to realize. The "cabbage snake," so called, commonly found, is shown in Fig. 16. It is an "eel-worm" or "hair worm," and occurs as an internal parasite in the bodies of grasshoppers, happening at times to escape from its host onto cabbage heads, which alone accounts for its presence there. These slender, thread-like creatures are active and repulsive looking, but never poisonous.

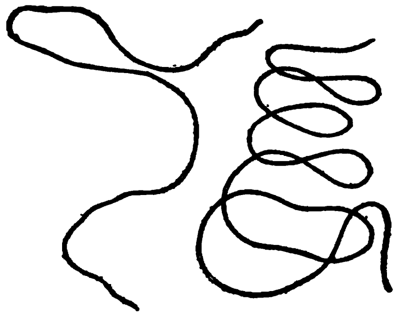


FIG. 16.—"Cabbage Snake" or Hair-Worm: Natural size. (Chittenden, Cir 62, Bur. of Ent. U. S. Dept. of Agr.)

Small, segmented, reddish earthworms occasionally get into cabbage heads, by being accidentally lodged there with small clods of earth during cultivation. There is no danger from eating cabbage that have contained these worms, or the common "cabbage snake."

INSECTS AFFECTING THE CELERY PLANT.

CUTWORMS.—(See under Bean Insects, p. 11).

CELERY CATERPILLAR *(Papilio polyxenes*, Fab.).

This is a very large, conspicuous green and black caterpillar, familiar to many children because of its peculiar appearance. It seldom appears in great numbers, but if present is a voraceous feeder on various plants, including celery, carrot, parsley, caraway, parsnips, and related wild plants.

DESCRIPTION AND HABITS.

Caterpillars.—Are about two inches in length, green in color, with rings of black, which in turn bear yellow spots. The head bears a pair of horn-like processes that may be thrust out and which emit a disagreeable odor. The body is thrown into a peculiar defensive like attitude when disturbed.

Pupæ.—When full grown the caterpillars generally desert the plants on which they fed and crawl to some convenient place to pupate. The pupæ are naked, of an ash-gray color, and are suspended by a silken band and mat of silk at the caudal end. In this quiescent stage they pass the winter.

Parent Butterfly.—The adult form, commonly known as the "black swallow-tail," is very conspicuous. The wings are blackish-brown, and marked with yellow and orange bands and spots.

REMEDIES.

As there may be several broods each season the gardener should be on the watch for their first appearance. The caterpillars are so conspicuous that hand picking is probably the best remedy, and if the larvæ of the first brood are destroyed later injury may be prevented. Paris green mixture (See p. 60) will be found effective and might be used with profit on the young plants in extensive celery fields.

OTHER CATERPILLARS ATTACKING CELERY.

Celery Looper, *Plusia simplex,* closely related to the cabbage looper, and the celery leaf-tyer, *Phlyctænia ferrugalis,* is a small caterpillar that usually feeds on the terminal leaves and may at times become troublesome. Spraying young plants with arsenical poisons should prove effective, and is perfectly safe if the poison is used in reasonable amounts.

CELERY LICE.

Celery is occasionally infested with plant lice of various species, whose attack results in lessened vitality and dwarfed plants. Should this occur, a thorough spraying with soap solution, as suggested for cabbage aphis, p. 18, will be found effective. Soap solution may be applied frequently without injury. Tobacco decoction is always quite effective against plant lice.

RED SPIDER *(Tetranychus spp.)*.

These little creatures, frequently called mites, are not true insects. They are, however, a very common garden pest, and attack at times almost any vegetables, particularly cucumbers, cantaloupes, egg plants and many common crops. They are most abundant during hot, dry weather, and then if present they cause the foliage to turn yellow and eventually die. The individuals are very small and rather active; and may feed on both upper and lower surfaces of a leaf, spinning over it a thin web for protection.

REMEDIES.

Abundant moisture will keep red spiders in check. When a good spray or force pump is available, they may be controlled by simply making frequent applications of ordinary clear water, applied with all the force the plants will endure, washing both sides of the leaves. This method is used in greenhouses, to keep the mites off of violets, roses and other plants.

Powdered sulphur (flowers or flour of sulphur) applied as a fine spray, using one ounce of sulphur in a gallon of water or the dry powder dusted on the plants when wet with dew will be found very effective. Potassium sulphid *(liver of sulphur)* obtainable from drug stores, may be used as a spray of one ounce in three gallons of water. It is said that a little whale oil soap, tobacco-stems water, or milk of lime added to the sulphur mixture increases its efficiency.

INSECTS AFFECTING SWEET CORN.

Numerous insects attack corn, some injuring the seed when first planted, some damaging the young plants, others attacking the stalk and ears when partly grown, while still others damage the stored grain. Only the most common injurious forms will be mentioned here, as the entire space of a bulletin is needed to adequately discuss all the corn insects.

WIREWORMS *(Several Species)*.

These insects hardly require description, as they have become so well known by their attacks on various crops. Wireworms injure corn by the larvæ boring into the kernels when first planted and later by entering into the stalk of young plants, causing them to die in the same way as when injured by budworms or rootworms.

DESCRIPTION AND HABITS.

Larvæ.—Wireworms in general may be described as having long, slender, cylindrical, firm bodies, showing segmentation, usually flattened toward each end. They vary in size according to the species to which they belong, some being less than one, others nearly two inches long. The majority are reddish or yellowish in color, presenting a very hard, slick appearance. Some wireworms feed on decaying wood and organic matter, while others subsist on seeds and roots of plants.

Parent Beetles.—These are commonly known as Jack snappers, click beetles, thumping beetles, and by other terms, gained for them by the power of springing several inches in the air, in an effort to turn over when laid on their back.

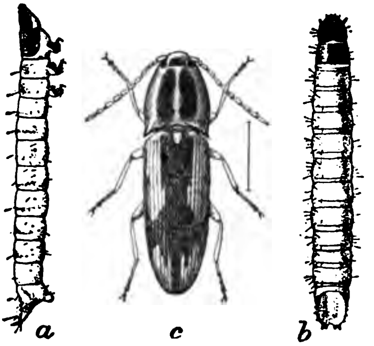


FIG. 17.—Wireworms: Larvæ and adult—all three times natural size. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

The common click beetles are from one-third to one inch in length, generally of a brown color and are variously marked. A common species is pictured in Fig. 17.

LIFE HISTORY.

The parent beetles may hibernate in protected places, but many larvæ pass the winter in the soil. It is thought that most species of wireworms require three years to mature, hence two winters of their life must be passed in the ground. This fact shows how difficult it may be to free a field from these pests. The beetles of the injurious species, generally deposit their eggs in grassy places, though the species that feed in decaying wood may lay eggs in old stumps, etc.

REMEDIAL MEASURES.

No single method of control is effective. Various methods of reducing the numbers of wireworms in fields already badly infested have been advocated. The most promising are, early fall plowing to disturb the larvæ, followed by cross plowing and harrowing once or twice during winter, and the use of poison baits in spring. A good bait is made by treating slices of potatoes or turnips with strichnine, and other baits are mentioned under remedies for cutworms, p. 14.

Crops peculiarly liable to attack, like corn, potatoes, beets, turnips, etc., should never be planted on land known to be infested, unless absolutely necessary.

Rotation of crops may do some good. It is difficult to name an immune crop. Legumes, as a rule, are not much injured by wireworms, but that may be due to their abundant root system. A rotation that allows the land to be broken every fall or winter will naturally tend to reduce the numbers of these insects.

Planting an excess of seed when corn must be planted on infested land may insure getting a stand.

Corn Rootworm (Budworm), *(Diabrotica 12-punctata,* Oliv.).

This corn pest belongs in the same category as the wireworms in being difficult to control. Rootworms damage young corn plants by eating into the stalk at or near the ground, and very young plants may be killed outright, while older ones will be caused to make a dwarfed growth because of having the central bud destroyed. Fig. 18 illustrates the insect in its different stages, and an injured plant.

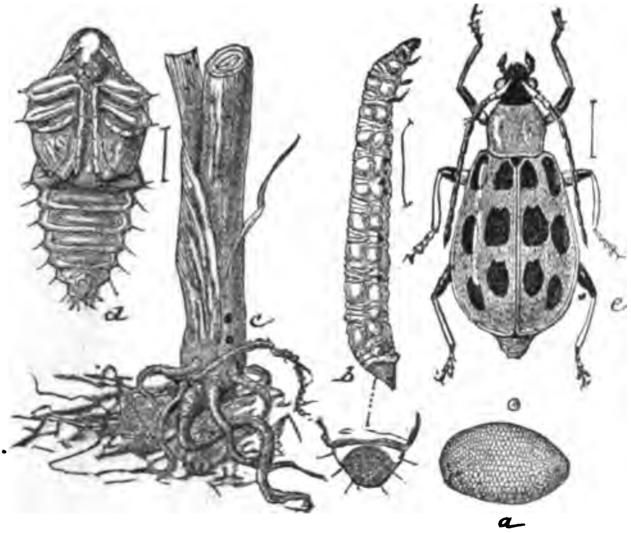


FIG. 18.—Corn "Root-worm" or "Bud-worm": *a*, egg; *b*, larvæ; *c*, injury to corn plant; *d*, pupa; *e*, adult beetle—all except *c* much enlarged. (Redrawn from Riley, Div. of Ent., U. S. Dept. of Agr.)

DESCRIPTION.

Larvæ.—These are slender, yellowish white grubs with a brown head and body about one-half inch long. They attain full growth in three to four weeks.

Pupæ.—The larvæ change to naked whitish pupæ in little cells in the soil, and after about two weeks transform again to beetles.

Parent Beetles.—Are about three-tenths of an inch long, yellowish green in color, with twelve black spots on the wings as illustrated in Fig. 18, much enlarged. These beetles are omniverous feeders on a great variety of plants, notably cucumbers, cantaloupes, etc.

LIFE HISTORY.

After passing the winter in hibernation the beetles become active early in the spring. The earliest vegetables of the garden serve as their food, working, as they do, side by side with cucumber and flea beetles. The eggs, deposited in the soil close by the base of corn plants, hatch within a short time and the newborn larvæ burrow into the stem as indicated above.

There are at least two generations, the first maturing within about six to seven weeks after the eggs are deposited. The parent beetles are present all summer, often feeding on the blossoms of fruit trees.

REMEDIES.

Commencing in early spring and following this insect through its two generations, we discover no good chance of destroying the larvæ, but there is some opportunity of killing the pupæ in the soil and of poisoning the adult beetles. The latter method, however, offers only a slight chance, for the beetles do not all feed in the gardens. Still the liberal use of poisons on cucumbers and cantaloupes, as recommended on page 43, will undoubtedly destroy some of them. Some of the pupæ may be killed by thorough weekly cultivation of the corn crop, especially during and about the sixth to tenth week after it comes up.

Good fertilization to strengthen and feed the corn plants will aid materially against slight attacks, and planting an excess of seed will often insure a stand even though the rootworms may be abundant.

Late Planting and Lowlands.—Delaying the planting of corn until two or three weeks after the usual time will allow many beetles time to deposit eggs elsewhere, thus gaining some protection. The ideal time to plant corn must be determined by experience. Corn rootworms are *liable* to be most abundant in lowlands—but they are not very choice in the selection of a feeding ground—hence some advocate the avoidance of such lands for corn.

As Sherman,[1] in writing of corn insects, has said, "All these measures will help '*some,*' but no one alone will insure immunity from attack of rootworms."

---

[1] Bul. N. C. Dept. Agr., Vol. 26, No. 5.

LARGER CORN STALK BORER (*Diatræa saccharalis*, Fab.).

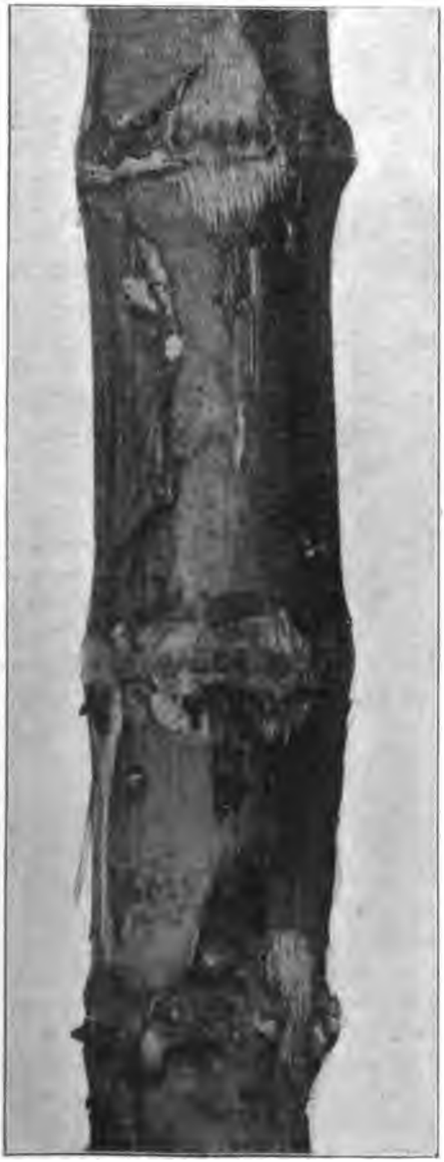


FIG. 19.—Corn stalk, showing holes made by corn stalk borers. (Photo. by the author.)

Corn is often injured by a caterpillar boring in the stalk, usually most noticeable and injurious when the corn is about half grown, but young plants may be destroyed. These borers weaken the stalks, retarding the development of the ears and sometimes render large stalks worthless except for fodder. These insects are said to be most abundant during the latter part of May or early in June.

DESCRIPTION AND HABITS.

Larvæ or Borers.—These burrowing caterpillars are about one inch long, with whitish, robust bodies, speckled with brown and black spots (Fig. 20). They confine their attack mainly to the three lower joints, and may occur without apparently affecting the growth. The larvæ, however, are very active, often leaving their burrows and making new entrance holes, thus severely weakening the stalks (Fig. 19).

Pupæ.—The pupæ, usually found in the stalk above ground, are of a shiny, brownish color and are about one-half inch long.

Parent Moths.—The adult moths have a wing expanse of about one and one-half inches; the fore wings are dull yellowish brown, or nearly colorless; hind wings white or cream colored. The moths of the first brood appear in Georgia (where the writer studied this insect) from the middle of June to the middle of July. They probably appear about the same time in North Carolina.

LIFE HISTORY.

The reader will understand that there are two broods each season. The first brood are the progeny of the insects that pass the winter in the pupal stage, in corn stubble (presumably), while the second brood are the progeny of the moths that appear during June and July.

Corn is damaged most severely by the first brood, for at that time the plants are small or only partly grown. Late planted corn may be injured badly by the second brood. It seems highly probable that the corn stalk-borer has some wild host plants, some common weeds, in which many larvæ of the second brood mature. Howard[1] has reported its occurrence in Gama grass, and there must be other wild host plants. The insects pass the winter as pupæ, probably, to some extent at least, in corn stubble.

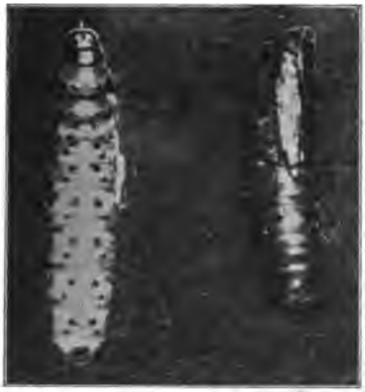


FIG. 20.—Larva and pupa of corn stalk borer. On left larva; on right, pupa—twice natural size. (Photo. by the author).

REMEDIAL MEASURES.

No truly effective remedy can be offered. It has been suggested that corn planted as late as May 15 to June 1 might escape injury. still it might also be attacked by larvæ of the second brood. When the stalk borers are observed the gardener should arrange to plow out, rake and burn the stubble as soon as the corn is harvested. Cutting the plants off at the surface of the ground will probably serve to trap nearly all the larvæ or pupæ that may be present, but such infested stalks should be fed to stock or hogs or used for ensilage. When corn is badly infested by stalk borers it would be best to use it for fodder or the silo, taking the precaution to cut the corn before many of the borers change to pupæ. The gardener can ascertain this point by frequently examining the corn plants for the presence of the brown pupa, which will certainly be found when the worms are full grown.

---

[1] Insect Life, Vol. IV.

Rotation of crops is of course beneficial, but it must be remembered that the moths are capable of flying some distance in spring in search of young corn in which to deposit eggs.

Deep fall or winter plowing of corn land may serve to bury some of the pupæ so that the moths can not escape.

CORN EAR WORM *(Heliothis obsoleta,* Fab.).

This insect does not by any means confine its attack to corn, though this is perhaps its favorite food plant. It may bore into cotton bolls, and is then known as the cotton-boll-worm. When it attacks beans, peas, tomatoes, okra, tobacco and other crops, it is generally known by the name of the plant on which it occurs. The wide variation in the color of the larvæ largely accounts for its having so many names.

DESCRIPTION, HABITS AND LIFE HISTORY.

The parent is a night-flying moth, the wings of which expand about one and one-half inches and range in color from dull yellow to olive green with black markings (Fig. 21). The moths that appear in early spring, having developed from pupæ that passed the winter in earthen cells, seem to prefer to deposit eggs on young corn, and later on the silk, particularly when that is present. The larvæ, small at first, grow rapidly, attaining a length of about one and one-quarter inches, and range in color from greenish to dark brown. The markings are shown in Fig. 22.

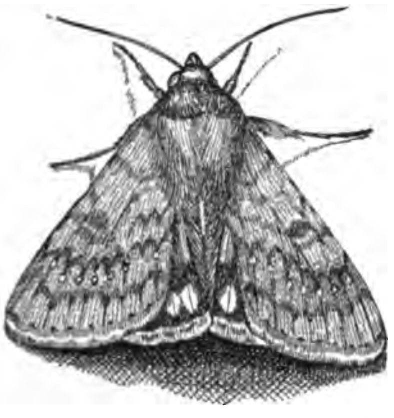


FIG. 21.—The Corn Ear-worm, showing adult moth in natural position with wings not spread —about twice natural size. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

Sweet corn is injured more severely than common field corn, but as the former is so much more preferable for table use the gardener should prepare to fight this insect.

There may be four or five broods each season, each successive brood gaining in numbers. When corn becomes hard, the moths deposit eggs on cotton, seeming to know instinctively that it will make better food for the larvæ.

REMEDIES.

The only direct remedy consists in pinching the tips of infested ears of corn to crush the larvæ within. A few rows of sweet corn may be treated in this manner. The pinching must, however, be done several times and at intervals of only two to three days, as the small larvæ may escape.

Trap Plants.—Remembering that the moths prefer corn silk on which to deposit eggs, we have an opportunity of using a few hills of *very early planted corn* as trap plants. Early maturing varieties should be used. The larvæ are cannibalistic, devouring each other when more than one are present in a single ear, hence the trap plant is peculiarly valuable. Trap plants must be watched and destroyed, or at least the worms destroyed before any become full grown and descend to the ground to pupate. Garden crops other than corn may be protected by having a few hills of corn in silk when the other crops would ordinarily be injured.

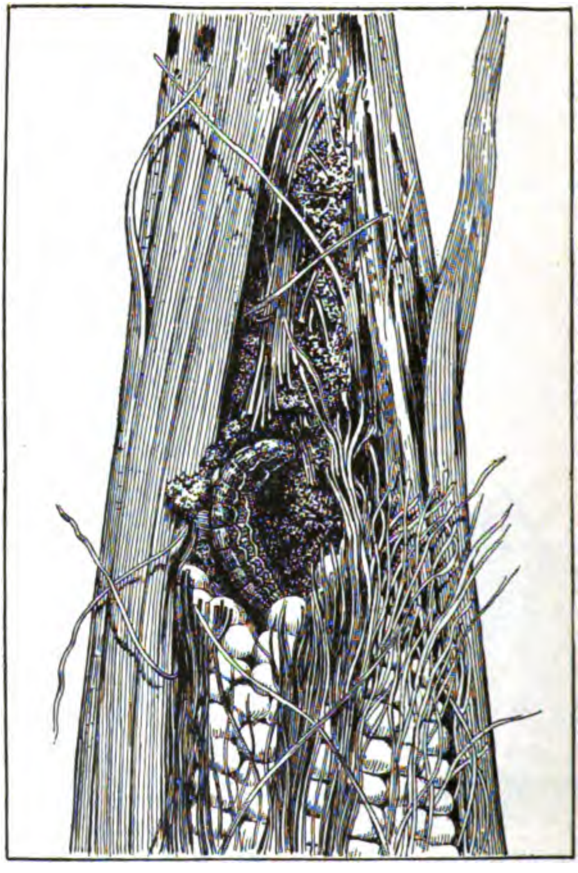


FIG. 22.—The Corn Ear-worm, showing the destructive larva at work in ear of corn. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

Winter Plowing.—As already stated, these worms usually appear in cotton fields after the corn becomes hard, and hence it will be seen that the last generation is most liable to pass the winter as pupæ in such lands, rather than in garden or corn fields. Winter plowing of cotton fields, and gardens, where late corn has been grown, will kill many pupæ.

CORN WEEVILS *(Larvæ of Beetles and Moths).*

Stored corn, shelled or otherwise, is often infested with white grub-like larvæ, which may be the young of the rice-weevil *(Calandra oryzæ,* Linn.), or the granary weevil *(Calandra granaria,* Linn.), or the larvæ of the Angoumois grain moth *(Sitotroga cerealla,* Ol.). The latter is common, though the two former are better known. The two weevils are shown in Fig. 23, and the grain moth in Fig. 24. Corn may become infested with weevils in the field, but the grain moth is most liable to attack the stored corn.

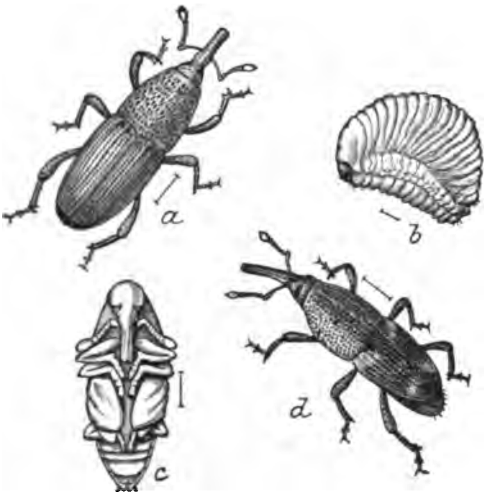


FIG. 23.—Corn Weevils: ***Calandra granaria;*** ***a***, beetle; ***b***, larva; ***c***, pupa. ***C. oryzæ***, ***d***, beetle. All enlarged. (Chittenden, Farmers' Bul. 45, U. S. Dept. of Agr.)

As there is no known practical method of protecting the corn in the field we will not take space to describe these insects, but pass at once to the matter of remedies.

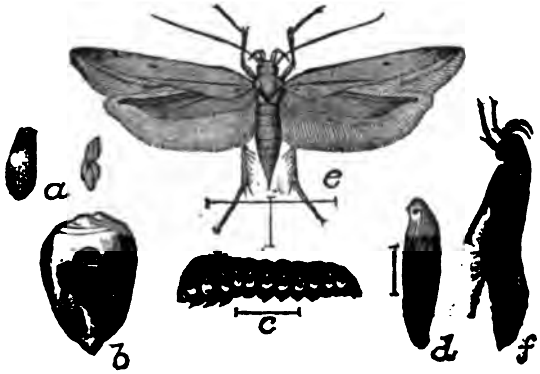


FIG. 24.—Angoumois Grain Moth: ***a***, eggs; ***b***, larva at work; ***c***, larva; ***d***, pupa; ***e***, ***f***, moths—all enlarged. (Chittenden Farmers' Bul. 45, U. S. Dept of Agr.)

REMEDY.

Fumigation.—Carbon bisulphid, a clear, foul smelling liquid that costs about 25 cents a pound is a certain remedy when properly used. Infested corn may be fumigated in ***air tight bins*** by using at least one and one-half or two pounds of carbon bisulphid for about one hundred bushels of grain. The grain moth is killed more easily than the true weevils, and for the latter it may be necessary to considerably increase the recommended amount. This remedy is often condemned and declared worthless because attempts made to fumigate the corn in loose, leaky bins have failed. It evaporates rapidly and the fumes are heavier than the air, so that they will settle and escape if any cracks are left in the bottom and sides of the bin or receptacle used for the fumigating chamber. The top must be closed or covered with something, such as wet blankets and boards, to keep out any currents of air. To fumigate, expose the liquid in shallow dishes near the top of the space, or pour it directly onto the corn, afterawrd leaving the place tightly closed for twenty-four to thirty-six hours. The fumes do not act immediately, like some other poison gases, and for this reason it is necessary to prevent even gradual leakage. When corn can not be treated in an *air tight* chamber, the amount of carbon bisulphid should be increased, but even then, under these conditions, the results may not be satisfactory.

Adult weevils and larvæ may be killed by fumigation except in certain cases when they are uncommonly well protected in the kernels, but as eggs which are not killed by fumigation may be present, it is generally necessary to repeat the treatment once or twice before corn is entirely freed from weevils.

Ordinary fumigation does not injure corn for eating or planting.

Caution.—The fumes of carbon bisulphid are highly combustible and explosive, hence lighted cigars, lanterns, etc., should not be brought near where the fumigation is going on. Breathing the fumes should be prevented, as they may cause a slight or severe headache. Some people are quite easily affected.

INSECTS AFFECTING CUCUMBERS AND CANTALOUPES.

CUTWORMS *(several species)*.—(See under Insects Affecting Beans, p. 11).

RED SPIDER.—(See under Insects Affecting Celery, p. 31).

MELON PLANT LOUSE *(Aphis gossipii,* Glov.).

Young cucumber, cantaloupe and similar plants may be attacked by small green sap-sucking lice that often cluster in great numbers on the under sides of the leaves. This same louse occurs on young cotton and is then known as a cotton louse. It is capable of causing severe stunting of growth and even death of badly infested plants. It occurs all through the summer months, sometimes injuring cantaloupes when the vines are several feet in length.

DESCRIPTION AND LIFE HISTORY.

Plant lice, of nearly all species, breed by giving birth to living young, the adults being both winged and wingless, as shown in Fig. 25. Many generations are developed each season and during the summer the colonies of lice contain no true males or females. This development is known as parthenogenesis, that is, the young are born by females without the intervention of the male. The melon louse is no exception to this rule. True males and females are developed by the last fall brood and the oviparous females deposit eggs to carry the insects through the winter. These eggs hatch in spring into minute lice that develop into viviparous females, whose young are born alive, as already explained.

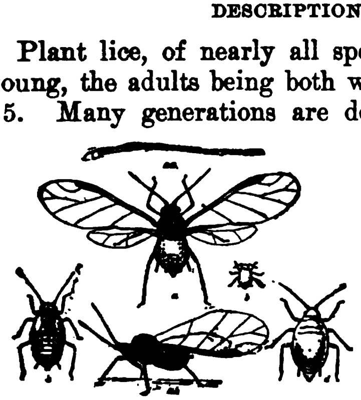


FIG. 25.—The Melon Aphis, *Aphis gossypii*: much enlarged. (Chittenden, Bur. of Ent., U. S. Dept. of Agr.)

The melon louse is yellowish green in color and about one-twentieth of an inch in length. The winged individuals of the colonies serve to spread the species, and their presence accounts for the isolated colonies that appear during the summer months. Individuals mature in six to eight days, and each gives birth to about fifty young. Considering this rapid increase it would seem that all infested plants would be destroyed, and such would be the case were it not for the valuable work of parasites, both internal and predaceous, that destroy great quantities of them. With these facts in mind, let us enter upon a consideration of the methods of control.

REMEDIES.

Spraying.—Contact poison sprays as used against cabbage lice (See p. 18) may be employed to kill isolated colonies that appear in spring.

Fumigation.—Within recent years a method of fumigating cantaloupe plants has been quite well perfected. Sanborn[1] has made valuable experiments with specially prepared tobacco or nicotine fumigating papers, manufactured and sold under the names nico-fume tobacco paper, aphis punk and to-bac-ine (See p. 64), and has perfected a system of fumigating by the use of cloth covered frames. The following description of a fumigating outfit is based on Sanborn's work:

Cloth Covered Frames.—For fumigating vines from two to four feet long construct a light wooden frame square or rectangular, of the desired dimensions, and nail an eight-inch leg to each corner. This may be covered with heavy muslin saturated with linseed oil to render it air-tight. Cut the muslin in pieces large enough to cover the frame, and also extend one foot over each side, and tack to the top, but not to the legs of the wooden frame. The loose edges of the muslin may be covered with earth to prevent any escape of gas. A frame of this construction makes a perfect fumigating arrangement, as it can be placed over any portion of a long vine if desired without damage and without disturbing the vine.

---

[1] Texas Expt. Sta. Bul. 89.

Method of Fumigating.—Use the tobacco papers, as recommended (p. 64), fumigating the infested plants from 20 to 30 minutes. This will kill all the aphis under the frames without injuring the plants. This method is said to be comparatively cheap and it is undoubtedly effective, much more so in fact than the best spraying that could be done. By having several frames in operation one or two men may fumigate large areas in the course of a day.

Beneficial Parasites.—As already stated parasites render valuable aid in controlling the melon lice. In Texas, Sanborn has shown that it pays to induce the increase of parasites by planting Rape, which usually bear the cabbage lice in abundance. This plant furnishes food in fall for a number of predaceous parasites, such as lady-bird beetles and their larvæ, that feed on the cabbage lice, and the beetles hibernate during winter among the weeds and rubbish and thus are usually present in the spring and ready to attack the first broods of melon lice. Rape, as a trap plant, should be planted in summer and fall in the gardens or on the edge of the fields where cantaloupes and cucumbers are to be planted the following year.

STRIPED CUCUMBER BEETLE *(Diabrotica vittata,* Fab.).

Here we have one of the commonest and most destructive of all insects that feed on the foliage of cucumbers and related plants. It is also a difficult one to control.

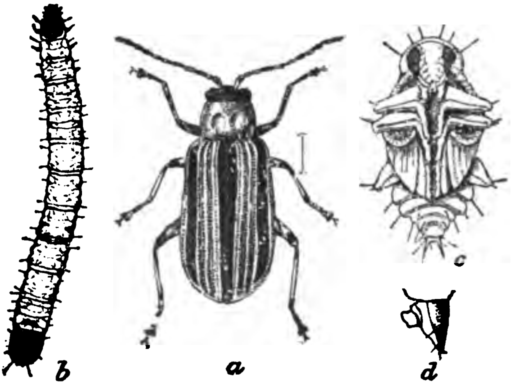


FIG 26.—Striped Cucumber Beetle: *a*, beetle: *b*, larva; *c*, pupa—all much enlarged. (Chittenden, Cir. 31, Div. of Ent., U. S. Dept. of Agr.)

DESCRIPTION AND LIFE HISTORY.

Beetles.—These small, yellow winged beetles, only two-fifths of an inch long, marked with longitudinal black stripes on the wing covers (Fig. 26), usually appear early in the spring. They are voracious feeders and cause much damage to young plants. They hibernate during winter.

Eggs and Larvæ.—Eggs are deposited at the base of young cucumber plants and hatch into small, slender, whitish larvæ that feed on the tender rootlets. The larvæ may attain a size of about one-third inch. They cause plants to wither and sometimes die. Such injury is generally overlooked by gardeners or else is laid to cutworms. The larva matures in about one month, and after passing through the pupa stage, lasting about two weeks, the change to the adult takes place.

REMEDIAL MEASURES.

All plants subject to attack should be protected from the ravages of the beetles from the moment they appear above ground until several leaves are formed, after which the plants are better able to withstand the injury. This protection is best afforded by suitable covers, but certain repellent sprays and powders may be used with profit.

Cover Protection.—The cheapest and most effective protection is afforded by box frames, about one foot square, covered with fine wire or mosquito netting, or, in the manner sometimes suggested, by cutting a barrel hoop in two to form two semi-circles, and pressing these down, crossing each other over the plants and covering all with netting. The lower edge of the cover may be held down with earth. The writer believes that the perfect protection given by these covers, allowing the plants to grow for three or four weeks without injury, more than repays the cost of material and the trouble of fixing them in place.

Spraying and Dusting.—A combination repellent and poison in the form of Bordeaux-Paris green mixture (See p. 61) is the next best thing to a cover protection. The poison Bordeaux serves as a protection against the cucumber beetle, and all leaf eating insects that may be present, and furthermore serves as a fungicide to keep the foliage healthy. When liquid spray is used this is the most economical.

A dry mixture of lime and Paris green (See p. 60) will poison many beetles and also act as a repellent, and simply dusting plants with tobacco dust, kerosene and lime mixture, or hellebore offers considerable protection, but the liquid poison spray is the most efficient. Dry applications should be applied when plants are wet with dew and repeated after every shower.

Trap Plants.—A few *very early* planted cucumber plants liberally treated with poison spray may serve to lessen the number of striped beetles and also Flea beetles, 12-spotted Diabrotica (adult of corn rootworm) and all leaf eating insects present at that time.

Planting an excess of seed is advisable if the protective measures suggested can not be used. The plants should not be thinned out too early, as some may die from the attack of the larvæ on the roots or from other causes.

Clean Culture.—Gardens should be cleaned up and all weeds and rubbish removed and burned during late fall or winter. This does away with the chance of leaving convenient hiding places in which this and many other garden insects may hibernate during winter. Fence rows should be cleaned out, and sod land adjoining gardens may be burned over to help destroy hibernating insects.

CUCUMBER FLEA BEETLE *(Epitrix cucumeris,* Harr.).

These small, black, jumping beetles (Fig. 27), about one-twelfth inch in length, often cause quite severe injury by eating the foliage of cucumbers, cantaloupes, melons, etc. The larvæ of this species is a leaf-miner, causing some damage, while the adults feed on the surface.

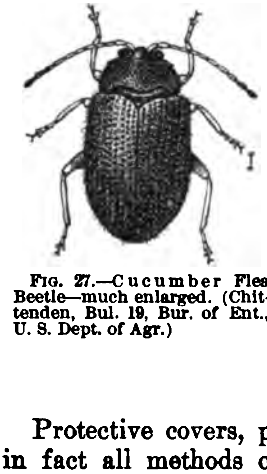


FIG. 27.—Cucumber Flea Beetle—much enlarged. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

Other Flea Beetles.—Several different species of flea beetles occur at times, and injure cabbages, turnips, potatoes, beans and many garden plants. The larvæ of most species feed on the roots of Jimson or other common weeds. The beetles all get their name from their ability to jump, due to thickened and muscular hind legs like those of the grasshopper.

REMEDIES.

Protective covers, poison and repellent sprays, and powders, and in fact all methods of control suggested above against the striped cucumber beetle are effective against flea beetles.

PICKLE WORM *(Diaphania nitidalis,* Cramer).

Growers of cucumbers and cantaloupes need no introduction to this troublesome pest that bores into cucurbits, rendering them unfit for table use or for market. The injury is caused by the larvæ. This borer is frequently called the melon worm or cantaloupe worm, but we will consider it as the pickle worm because a closely related species is now known as the melon worm. (See p. 57).

DESCRIPTION.

Eggs and Larvæ.—The eggs are generally laid in masses in blooms or tender buds. They are at first white, but change to yellowish green before hatching into small whitish worms. When grown the larvæ are yellowish green in color, about three-fourths of an inch long, and have eight pairs of legs.

Pupæ.—Light silken cocoons are spun in a fold of a leaf of the food plant, or on weeds close by, and here the pupæ are formed, changing later to adult moths.

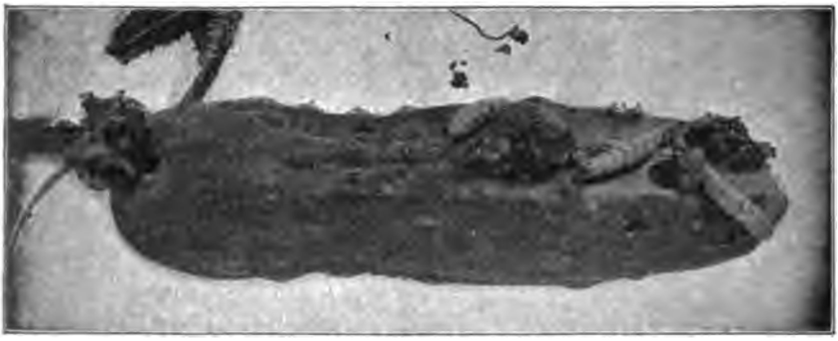


FIG. 28.—Pickle Worms working on cucumber. (Quaintance, Bul. 45, Ga. Exp. Sta.)

Parent Moths.—The moths have a wing expanse of about an inch; the color is yellowish brown, marked with yellow areas. The body terminates in a prominent brush like that of the melon worm (Fig. 37).

LIFE HISTORY AND HABITS.

The average life cycle of the pickle worm was determined by Quaintance[1] in 1901 as being from 24 to 27 days, showing that there may be at least four or more broods each year. The winter is passed in the pupal stage, always above ground in weeds or rubbish, which allows the gardener a chance of destroying great numbers by clean culture. The moths are nocturnal, hiding during the day. It seems that the first ones emerging from the over-wintering pupæ are somewhat late, appearing when the cucumbers or cantaloupes are well started into growth. The young larvæ may feed in opening buds, or at the base of the leaves, but soon attack the fruit. The greatest injury of course comes from their boring into the fruit, this being exaggerated by their habit of passing from one fruit to another. A great preference is shown for the blooms of squash (Fig. 29), and this may be made use of in protecting the cantaloupes and cucumbers as stated under remedies.

REMEDIAL MEASURES.

Very early planted cucumbers and cantaloupes for home or market use may escape injury from this pest, owing to the late appearance of the moths. Late plantings may be seriously injured, and there seems to be no absolute remedy to suggest. Trap crops, clean culture, and poisoning will all help to lessen the injury.

---

[1] Georgia Expt. Sta. Bul. 54.

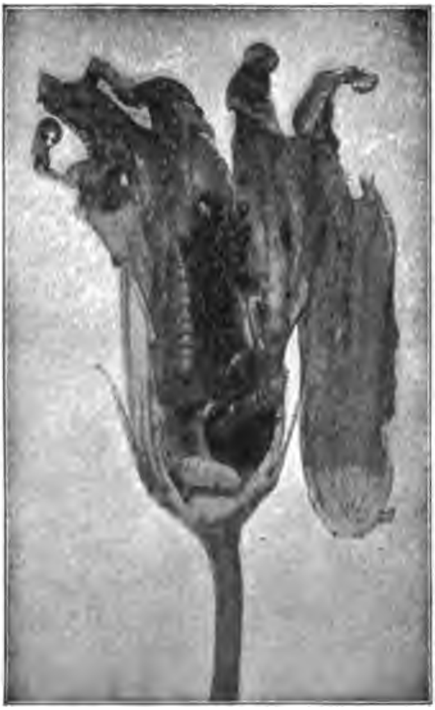


FIG. 29.—Pickle Worms feeding in squash blooms. (Quaintance, Bul. 45, Ga. Exp. Station).

Poison.—Dusting young plants with lime dust and Paris green may serve to poison some young larvæ that feed in the buds and flowers before entering the fruit.

Trap Crop.—Squash plants started early and planted among and near the crop to be protected are of great value if properly managed. The pickle worm larvæ feed freely in the squash blooms, and when this plant is used as a trap the infested blooms must be regularly gathered at least once a week and carefully destroyed to prevent any larvæ from maturing. Quaintance found that this crop offers very great protection, and when adopted squash seed should be planted every two or three weeks in order to furnish an abundance of blooms while the cucumbers and cantaloupes are developing. The squash plants might be poisoned also as a further protection.

Destroying Infested Fruit and Over-wintering Pupæ.—All infested fruit should be gathered and fed to hogs or otherwise destroyed to kill the larvæ within. As soon as the crop is gathered, rake up and burn the vines, together with all weeds and rubbish, to destroy any larvæ and pupæ that may be present. Deep plowing directly after the crop is gathered will no doubt stop further increase. and as another safeguard it is best to practice rotation of crops.

INSECTS AFFECTING THE EGG-PLNT.

Egg-plants are not subject to serious injury from insect attack, but some minor damage may occur each year. Some insect pests that may be expected are mentioned below:

APHIS (Plant Lice).—(See under Cabbage Aphis, p. 17).

COLORADO POTATO BEETLE.—(See under Potato Insects, p. 49).

CUTWORMS.—(See under Bean Insects, p. 11).

FLEA BEETLES.—(See under Cucumber Insects, p. 44).

HARLEQUIN BUG.—(See under Cabbage Insects, p. 18).

INSECTS AFFECTING THE ONION.

CUTWORMS.—Onion sets are liable to be seriously thinned out by cutworms, hence land on which onions are to be set should be carefully prepared, and freed as far as possible, from these pests by the use of poisoned baits as recommended on p. 12. When onions are grown in the field from seed an abundant supply should be planted to insure a stand, but the use of poisoned bait previous to sowing the seed should not be neglected.

ONION MAGGOT *(Pegomyia ceparum,* M.).

When plants in the onion beds commence to turn yellow, wilt, and die, from no apparent exterior cause, white maggots in the roots may be looked for.

As the life history and habits of this insect are so nearly the same as the cabbage maggot, the reader is referred to the description on p. 28.

Remedy.—In addition to the remedies suggested against cabbage maggots, gardeners may make good use of a carbolic acid emulsion, recommended by Slingerland,[1] whose formula is as follows:

Dissolve one pound of soap in one-half gallon of water, and thoroughly emulsify with one pint of crude carbolic acid. For use take one part of the emulsion to fifty parts of water.

This emulsion should be applied with a spray pump around onion plants, after first removing the surface soil. It is said to kill the maggots and also repel the parent fly from laying eggs.

Unleached ashes scattered over the beds just after the onions have come up is also said to repel the parent flies.

Infested fields should not be planted to onions the following year, and new seed beds should be placed as far away as possible.

INSECTS AFFECTING PEAS.

PEA WEEVIL *(Bruchus pisorum,* Linn.).
(And Other *Bruchus* spp.).

Belonging to the same genus as the Bean Weevil, but differing considerably in life history, the pea weevil *(B. pisorum)* is a common pest in stored peas. This species is a little larger (Fig. 30) than the bean weevil described on p. 15 and illustrated in Fig. 7. They differ materially, however, in the number of annual generations, for the pea weevil has only one, while the other may have several. Furthermore, only one larva of the pea weevil invades a single pea, and always gains entrance while the peas are green in the field. In other words, the pea weevil does not breed in dried peas, like the other species that have been mentioned.

---

[1] N. Y. Cornell Expt. Sta. Bul. 78.

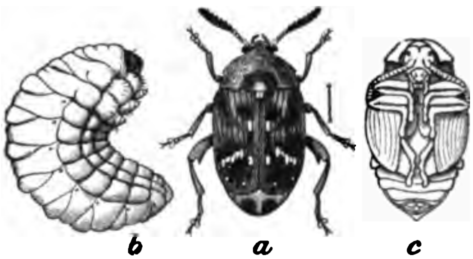


FIG. 30.—Pea Weevil, *Bruchus pisorum*: *a*, beetle; *b*, larva; *c*, pupa—much enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

The 4-spotted bean weevil (Fig. 8) may infest peas or beans, and unlike the common pea weevil, this species will breed in dried peas, producing successive generations like the bean weevil, hence any remedy against pea weevils must be one that will destroy all species present.

REMEDIES.

Fumigation.—If only the pea weevil *(Bruchus pisorum)*, that does not attack dried peas, were present, fumigation of peas would not be necessary. Simply placing them in perfectly tight receptacles until the adult weevils died would be sufficient. This condition may not occur, however, so we must prepare to fumigate to kill weevils whenever present.

Fumigation is the best remedy known, and carbon bisulphid is the material usually used. This clear, colorless, foul smelling liquid will kill the weevils, both larvæ and pupæ, but not the eggs. It is used, at the strength of one teaspoonful to a cubic foot of space, by placing the infested beans or peas in a perfectly air-tight receptacle, such as a large earthen jar, exposing the liquid on top in a shallow dish, and leaving the chamber closed for twenty-four hours. The liquid soon evaporates and the fumes, which are heavier than air, readily penetrate to the bottom.

Much loss might be prevented if gardeners would practice fumigation of peas and beans when first stored, but even when that is done they should be treated again if any weevils are observed later. As several broods may develop and weevil eggs may be present almost any time, fumigation must usually be repeated two or three times. The reader should refer to p. 40 for further information about carbon bisulphid and precautionary measures to be observed.

Uninfested peas or beans, if stored in perfectly tight receptacles, will remain free from weevils.

To insure getting good seed for planting, pour them in water, when the infested ones will float and may be discarded.

INSECTS AFFECTING IRISH POTATOES.

This valuable vegetable is subject to the attack of leaf-eating insects, such as Colorado Beetles, Flea Beetles, etc., and the tubers may be damaged by wireworms and white grubs. These pests, together with the stalk borer and others, must be fought successfully if potato growing is made profitable.

COLORADO POTATO BEETLE *(Leptinotarsa 10-lineata,* Say.).

This common potato pest is well known and frequently referred to as the potato bug, though the name beetle is more appropriate. It has been given the name Colorado potato beetle because of its being native to Colorado, where it formerly fed upon wild weeds belonging to the same genus as the potato plant. The Irish potato seemed to be much preferred by this insect, and when that vegetable was introduced it was speedily attacked.

Colorado potato beetles were first seriously injurious to potatoes in 1855, in Colorado, and since then have spread to the East and North, until now they occur in practically all of the potato growing sections of the United States and Southern Canada. Its natural spread was undoubtedly hastened by the parent beetles being shipped with potatoes. At the present time it appears to be omnipresent, for the potato patch can not be located where the beetles may not appear. For this reason the practice of rotating crops, so beneficial against certain other insects, does very little good in this case.

DESCRIPTION AND HABITS.

Parent Beetles.—It has been said that these beetles perch themselves on clods of earth and await the sprouting of potatoes in spring. This is almost literally true, for the adults pass the winter in protected places, and are among the first to appear in spring.

The beetles are ochre-yellow in color, with ten longitudinal black lines on the wing covers (Fig. 31). They do considerable damage by feeding on the foliage.

Eggs.—The eggs are deposited in flat clusters of fifty or more, on the under sides of the leaves. They are conspicuous orange colored. Each female may lay from six hundred to one thousand eggs.

Larvæ or "Bugs."—The soft bodied, reddish, hump-backed creatures, commonly called bugs, are voracious feeders, causing much more damage than the adults. In four to five weeks, they attain full growth after eating an enormous quantity of food, and then drop from the plants, enter the earth and form a smooth, oval cell (Fig. 31).

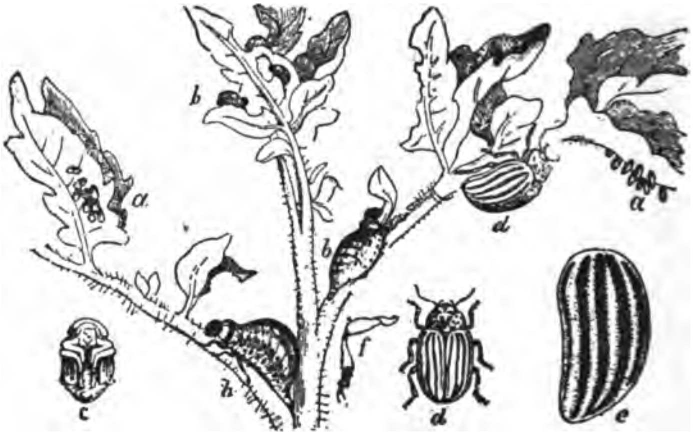


FIG. 31.—Colorado Potato Beetle: *a*, eggs on leaf; *b*, small and grown larvæ; *c*, pupa; *d*, adult beetle; *e*, enlarged wing-case of adult; *f*, enlarged leg of adult. (Riley, Missouri Reports).

Pupæ.—In the earthen cells the pupæ pass a motionless life for ten days to two weeks, and then transform to the parent beetles.

Generations.—There are probably four generations each year in North Carolina, the last beetles passing the winter in hibernation.

REMEDIES.

The voracious feeding habits of this pest, coupled with the power of the potato plant to withstand arsenical poisons, offers us a reliable remedy in the poison applications.

Arsenicals.—Paris green or arsenate of lead applied as a liquid spray is a perfect remedy. The former may be used at the greatest strength recommended on page 60 and the latter at the usual strength.

Dry Paris Green Mixture (See p. 60) may be dusted on while wet with dew or just after a rain by means of a good powder gun, or through a cloth sack, or a tin can with the top perforated like a pepper shaker. These poison applications will certainly control the Colorado potato beetles, but the grower should watch carefully for the first appearance of egg masses, and then be prepared to apply the poison to kill the young larvæ before the plants are defoliated. It is just as easy to poison the bugs before the foliage is injured—and certainly more economical.

No Danger From Arsenical Sprays on Potatoes.—The writer has met a few people who feared to apply the Paris green to potato plants, thinking that the tubers would absorb the poison from the foliage. There is absolutely no such danger, and practically no danger to the persons applying the poison.

Bordeaux Mixture and Paris Green.—We would particularly advise the use of Paris green in Bordeaux mixture (See p. 61), as it helps to keep the plants free from disease, and the poison so applied is not readily washed off by rains. Arsenate of Lead may be applied in the same manner.

THREE-LINED LEAF BEETLE *(Lema 3-lineata,* Oliv.).

This somewhat common potato pest is closely related to the Colorado beetle, but differs in size and color. The beetles are about one-fourth inch long, yellow in color, with three black stripes on the wings, resembling the striped cucumber beetles mentioned on p. 42. The larvæ are dirty yellow and may be recognized by the habit of covering the body with their own excrement. The eggs are orange colored, usually laid in rows along the mid-rib on the lower sides of the leaves.

When present these insects may be controlled by the remedies suggested against the Colorado beetle.

FLEA BEETLES *(Several Species).*

These small jumping beetles, usually black in color, riddle the leaves with small holes, but their work may be prevented by thoroughly spraying the plants with Bordeaux and Paris green mixture. The cucumber flea beetle, mentioned on p. 44, often attacks the potato plant. Poison dust sprays act both as a repellent and poison to these little creatures.

POTATO STALK BORER *(Trichobaris trinotata,* Say.).

As its name implies, the insect lives in the larval or grub stage in the stalk, boring through the heart, and when several are present, they severely weaken and generally kill the infested plants. The presence of only one or two is seldom noticed.

DESCRIPTION AND HABITS.

Adult.—The parents of the stalk borers are small, greyish weevils, about one-sixth inch in length, and having a strong, curved snout. They hibernate during winter, usually appearing early in spring to deposit eggs in the potato stalks. Otherwise they cause no apparent damage.

Larvæ.—Usually called grubs, are white or yellowish in color with brown, horny heads, and attain a length of about one-half inch. When grown they change to pupæ in cocoons in the stalk.

Life History.—There are two generations each season, the adult of the first appearing about the middle of July, while the adults of the later brood appear during August or September, and hibernate during winter. (See Fig. 32 for illustration of this insect.)

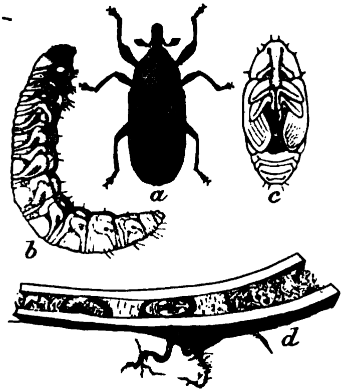


FIG. 32.—Potato Stalk Borer: *a*, beetle; (weevil); *b*, larva (borer); *c*, pupa—five times natural size; *d*, section of potato stalk opened to show larva and pupa *in situ*. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

REMEDIAL MEASURES.

It appears impossible to suggest a direct method for killing the borers in the stalks without destroying the plants, hence every effort should be directed toward keeping them from reaching the adult beetle stage, and thus prevent them from being numerous during the succeeding season. Infested plants, detected by their wilted appearance, should be pulled up and burned. After the potato crop is gathered all vines in the infested fields should be raked together, dried a few days, and then burned.

It is known that this borer breeds in the stem of the egg plant and wild plants, such as horse nettle, bull nettle, jimson weed, and many *solanaceous* plants. When these occur around infested potato fields they should be cut and burned, if possible, while the borers are in the stems, and thereby prevent the development of beetles.

WHITE GRUBS OR GRUBWORMS.

We will discuss white grubs under the head of "Potato Insects," though in reality they are often as injurious, and sometimes more so, to strawberries, corn, small grains and many tuberous rooted vegetables such as beets, turnips, etc. In fact most garden crops are injured at times by white grubs, which are more or less common in all localities. It is evident that these insects formerly subsisted on grass roots in the wild prairie lands, being native to this country, and turned their attacks to cultivated crops when deprived of their natural food by the cultivation of lands in which they lived. There are a large number of species of white grubs, some being feeders on decaying vegetable matter, manure, etc., and hence not injurious, while others subsist on the roots of growing plants.

GENERAL DESCRIPTION.

White grubs, in general, may be described as having thick bodies. and hard, horny heads, behind which are three pairs of true legs ending in claws, while their abdomens are usually distinctly enlarged near the caudal ends (Fig. 33, e). They lie in a curved position, as shown in the figure. Some species get to be nearly two inches long, while many are smaller. Practically all the most injurious forms belong to the genus *Lachnosterna.*

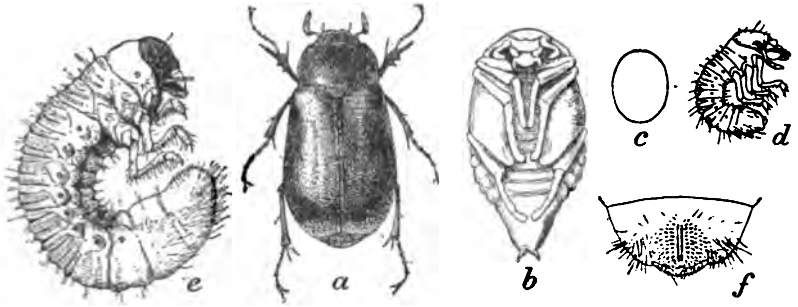


FIG. 33.—White Grub, *Lachnosterna arcuata:* *a*, beetle; *b*, pupa, *e*, larva—all enlarged one-fourth. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

Parent Beetles.—The parents are called May or June beetles, mostly shining brown in color and quite large, being known by their habits of flying into houses attracted by the lights at night. The beetles occasionally cause much injury to pecan trees and fruit trees by eating the developing buds.

LIFE HISTORY AND HABITS.

The eggs are deposited in sod lands, weedy places, strawberry beds, especially if the latter are weedy, and young grubs feed on the roots of almost any available plants. The eggs are laid from May to July, and the grubs require from two to three years to mature, this depending on the species.

It will be seen that land once infested may remain so continuously, and when disturbed by plowing, destroying the crop, strawberries, grass or whatever was on the land, the grubs must feed on the roots of the crops following. If potatoes are planted on sod land or old strawberry beds, they are liable to be seriously damaged by these insects, and the same would be true of most other vegetables.

When mature, the grubs transform to pupæ in earthen cells, and about August or September change to the parent beetle, which may remain in the cell all winter.

REMEDIES AND PREVENTION.

Insecticides.—These are not practicable in the writer's opinion, though liberal applications of Gas Lime or kerosene emulsion have been used on lawns with some success.

Rotation.—This is another case where an ounce of prevention is worth a pound of cure. Land known to be infested with white grubs should be sown in clover or some crop least liable to be injured by these insects, at least two years before planting in potatoes or any other tuberous vegetable. Corn land is liable to be infested, and here rotation is valuable. Sod land should never be planted to vegetables the first year after plowing. The rotation should be planned so that the land may be thoroughly plowed each fall or winter.

Fall Plowing.—This will undoubtedly kill some grubs by exposing them as prey to birds and fowls and by leaving them exposed to the winter's cold. By following fall plowing with a cross plowing or harrowing during winter when the condition of the land will permit, better results will be obtained.

Domestic Animals.—Chickens and turkeys should be encouraged to follow the plow, as they will pick up great numbers of all kinds of insects. Hogs delight to root for white grubs, and if turned into the garden and encouraged to root by scattering a little corn on the ground, they will render valuable service.

INSECTS AFFECTING THE SQUASH.

SQUASH BUG (*Anasa tristis*, DeG.).

Here we have another injurious sucking insect, and one that seems to inject a poison into the plant the same as as is the case with the Harlequin bug on cabbage. The name stink-bug is often applied to this insect, and to several related forms because of their disagreeable odor.

DESCRIPTION AND HABITS.

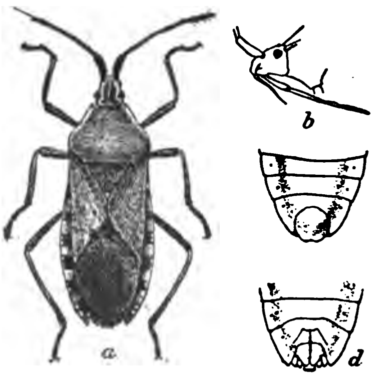


FIG. 34.—Adult Squash Bug: Twice natural size. (Chittenden, Bul.19, Bur. of Ent., U. S. Dept. of Agr.)

Adult Bugs.—These bugs are very generally known, but may be briefly described as being a little over one-half inch long (Fig. 34), dirty blackish brown above, and mottled yellowish beneath, the head bearing a long jointed beak that lies between the legs when not in use. They are nocturnal in their habits, and hide during the day under sticks, leaves, etc.

Eggs and Nymphs.—The brownish eggs are laid in irregular rows on the leaves, and hatch into small awkward looking creatures. These young, called nymphs, generally feed for a time in groups, and increase in size by successive molts, gradually developing wings. A dozen nymphs may seriously injure a small squash or melon plant, by the combined effect of loss of sap and poison injected.

Life History.—The adult squash bugs pass the winter in protected places, under rubbish in or about the gardens, or in fence corners, etc., appearing early in spring to deposit eggs. There may be several generations each year.

REMEDIES AND PREVENTION.

Hand Picking.—The first bugs appearing in spring may be collected by hand to prevent their depositing eggs. This practice is advisable all through the spring and summer, when plants are not otherwise protected.

Cover Protection.—Young plants may be protected by methods recommended on p. 43 under Cucumber Insects.

Trapping.—Trap plants started very early, planted indoors in strawberry baskets, if desired, and transferred to the garden, will be found very valuable. The bugs will collect on such plants and may be picked off by hand together with the egg masses. Bugs may also be trapped at all times under shingles, boards, or cabbage leaves. After feeding at night, they will hide under these traps, from which they should be collected each morning, particularly during early spring.

Spraying.—Poison sprays are obviously useless against this sucking insect, but kerosene emulsion of a strength of 10 per cent will kill the young nymphs when feeding in groups. Repellent sprays or powders (See p. 43) are of some value.

Clean Culture.—Burning all rubbish and old plants, both after the crop is gathered and during fall or winter, will do much toward preventing the adult bugs from hibernating successfully.

SQUASH VINE BORER *(Melittia satyriniformis,* Hbn.).

Damage from this insect is caused by the larvæ boring into the stalk, sometimes resulting in death of the infested stalk, and always causing a loss of vitality. Squash and pumpkin are the favorite food plants, but melons and cucumbers may be attacked.

DESCRIPTION.

Parent Moths.—The moths as described by Quaintance[1] have forewings opaque, shining olive brown in color, and transparent hind wings bordered by a narrow fringe of scales. The body is about three-fourths of an inch long, with a wing expanse of nearly one and

---

[1] Georgia Expt. Sta., Bul. 45, p. 47.

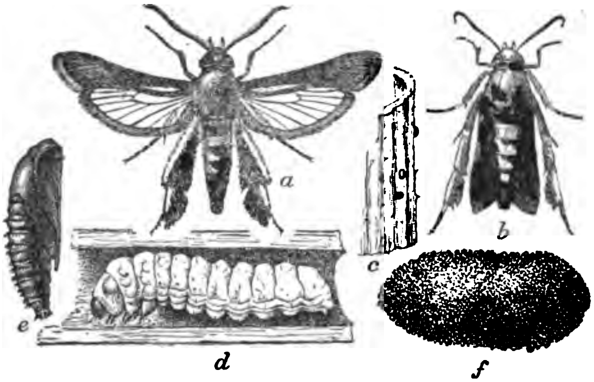


FIG. 35.—Squash-Vine Borer. *a*, male moth; *b*, female moth, wings folded; *c*, eggs on stem; *d*, larvæ; *e*, pupa; *f*, pupa cell—all one-third enlarged. (Chittenden, Cir. 38, Bur. of Ent., Dept. of Agr.)

one-fourth inches (Fig. 35, enlarged).

Larvæ and Pupæ.—The borers are about one inch long, whitish in color and grub-like in form. When grown, they leave their burrows and spin tough silken dirt covered cocoons (Fig. 36) near the base of the plant from which they emerged. In this cocoon the larva changes to a pupa and eventually to an adult moth, which escapes through the end, as illustrated in Fig. 36.

LIFE HISTORY.

Observations on the life history of this insect, made in Georgia by the writer, showed that the pupæ stage was from three to four weeks, and that adults of the first brood appeared about the last of June. The second and last generation pass the winter in cocoons, changing to moths in spring about the last of April. These dates are probably a little too early for North Carolina conditions.

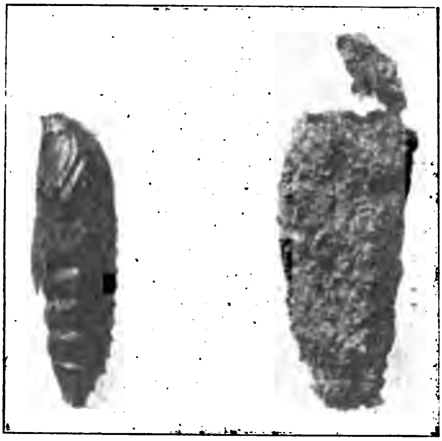


FIG. 36.—Pupa and empty cocoon of squash-vine borer— ; twice natural size. (Photo. by the author.)

TREATMENT.

The presence of borers may be detected by the accumulations of yellow excrement, cast out from the burrows about the base of the plants. Early in June this is frequently quite noticeable, and, when detected by the gardener, the borers should be carefully searched for and removed. This may be done without much additional injury to the plants, and is the only direct remedy. The borers of the first brood should be destroyed if possible.

After the crop is gathered the vines, root and all, should be pulled and burned to destroy any borers that might be within. As some borers of the second brood are liable to form cocoons before the plants are removed, deep fall plowing is advisable. This, coupled with prompt destruction of infested plants before the borers escape, should keep the pest reduced to insignificant numbers.

MELON BORER *(Diaphania hyalinata,* Linn.).

Closely related to the borer known as the pickle worm, described on p. 44, this destructive pest causes much damage by eating off the soft rind and boring into the squash, melon, etc. It differs from the pickle worm mainly in the habit of eating the foliage more freely and is therefore more easily controlled.

DESCRIPTION.

Parent Moths.—This is quite a beautiful moth described by Quaintance[1] as having wings of pearly iridescent whiteness, with a border of brownish black. The body color is white and brown, and the abdomen terminates in a large movable brush of elongated scales. The body is about three-fourths of an inch long and wings expand about one and one-fourth of an inch (Fig. 37, enlarged).

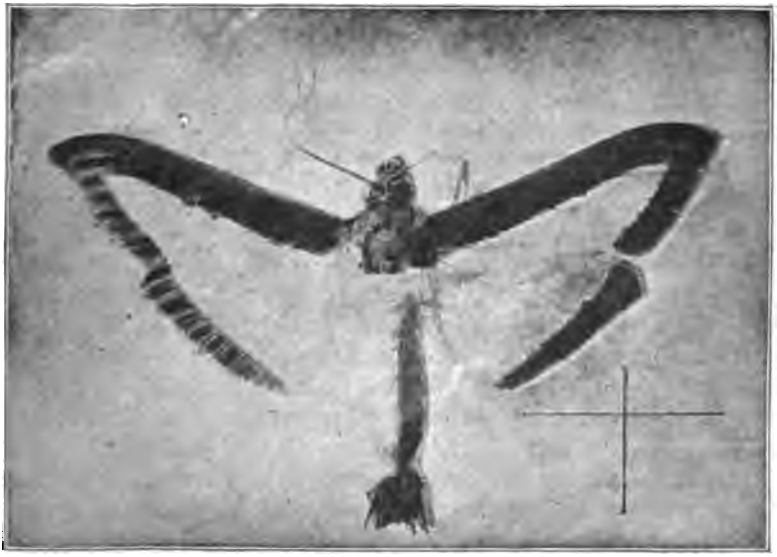


FIG. 37.—Moth, or parent of the Melon Worm: Much enlarged. (Quaintance, Bul. 45, Ga. Expt. Sta.)

---

[1] Georgia Expt. Sta., Bul. 45, p. 45.

Eggs and Larvæ.—Eggs are placed singly on the lower surface of the leaves, and hatch into active caterpillars, which when grown are slightly longer than pickle worms. They are of a pale greenish yellow color and possess a black head.

LIFE HISTORY AND HABITS.

The life history of this borer is nearly the same as the pickle worm. The greatest difference in habit is that of feeding on the foliage more than the pickle worm, and this gives the gardener an opportunity to make use of poison sprays. The melon borer seems to thrive best during rainy seasons.

REMEDIES.

Spraying is quite effective against the young borers that feed on the foliage. Paris green-lime mixture, Bordeaux-Paris green mixture, or arsenate of lead may be used. The gardener should watch carefully for the first brood of melon worms and be prepared to use the arsenical sprays quickly and thoroughly. Infested fruit should be fed to hogs or otherwise destroyed.

All the preventive measures recommended on page 45 against the pickle worm should be used against the borer, except the method of using squash blooms as traps.

INSECTS AFFECTING TOMATOES.

Cutworms.—(See under Bean Insects, p. 11).

Flea Beetles.—(See under Potato Insects, p. 51).

Potato Beetles.—(See under Potato Insects, p. 49).

Tomato Fruit Worm *(Heliothis obsoleta)*.

This is the same as the corn ear worm and the cotton boll worm. Under Corn Insects, p. 37, the reader will find a full description and also cultural methods of control. It is true that this is a difficult pest to fight, unless the gardener will study the habits of the worm, and learn how best to make use of corn as a trap crop, for there is no good remedy except to pick them off by hand. Corn as a trap crop, unless properly managed so as to destroy the worms that attack it, may serve only to increase the numbers of this pest.

Thorough spraying of tomato plants with Bordeaux-Paris green mixture, usually used against flea beetles and the green tomato worm, may result in poisoning some of the fruit worms. This should not be depended upon, however, for the worms eat only a small area of the surface of tomatoes.

TOMATO HORN WORM (*Phlegethontius celeus*, Joh.).

This conspicuous green worm is sometimes abundant enough to cause noticeable injury and occurs also on tobacco, and on that plant it is a very serious pest. This is the larvæ of a large, narrow-winged moth, belonging to the family *Sphingidæ* or Sphinx Moths.

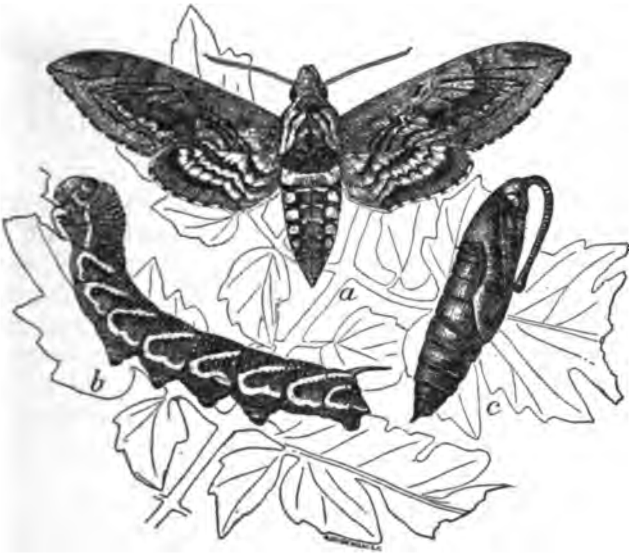


FIG. 38.—Tomata Horn Worm, *Phlegethontius celeus*: *a*, adult moth; *b*, full-grown larva; *c*, pupa—about two-thirds natural size. (Howard, Farmers' Bul. 120, U. S. Dept. of Agr.)

DESCRIPTION.

Larvæ.—Full grown worms are from three to four inches long, dark green in color, with oblique V-shaped white lines on each side of the body. The caudal end bears a prominent, long, sharp-curved horn that is quite characteristic. A closely related species of horn-worm, having straight white oblique lines on each side of the body is almost equally common.

Moths.—The moths have large, powerful wings, narrow compared to their length, and a robust body. The wings are brownish gray in general color with wavy markings and expand about four inches. The abdomen is marked on each side by five orange colored spots bordered with black.

REMEDIES.

Small fields of tomatoes, or especially a few garden plants, may be protected by picking the worms off by hand. Arsenical poison sprays used in connection with Bordeaux mixture is advisable, for this latter is of great value alone as a fungicide. Arsenical sprays may be used up to within ten days of the time the fruit ripens without danger of poisoning persons who eat the tomatoes.

FORMULAS AND DIRECTIONS FOR PREPARING SPRAY MIXTURE.

FOR BITING INSECTS.

Paris Green (as a liquid spray).

Paris Green	1 pound
Lime	2 pounds
Water	100 to 200 gallons
Or Bordeaux mixture	100 to 150 gallons

(See formula, next page.)

To prepare.—The combination of Bordeaux mixture and Paris green is often preferable to the simple water mixture with lime; but no matter what is used as a carrier for the poison, it should first be made into a thin paste with a small amount of water. This will prevent lumping and insure an even distribution of the poison in the mixture. When Bordeaux is used it is unnecessary to employ the extra two pounds of lime, but this should always be added to the simple water mixture. The lime unites with any free arsenic that may be present in Paris green, preventing burning of foliage that might otherwise occur.

Paris green, if absolutely pure, is entirely insoluble in water, but most commercial grades contain some water-soluble arsenic, the burning effect of which is overcome by lime. Paris green is really a very fine crystalline powder, and must therefore be held in suspension by constant agitation.

Plants with tough resistant foliage like potatoes and cabbage may be sprayed with one pound Paris green in 100 gallons of water, but tender plants such as tomatoes, beans, and celery, should be given a more diluted mixture.

Paris Green (in dry form).

Mix with from ten to fifty parts of cheap flour, land plaster, sifted air-slaked lime, ashes or fine dust and dust evenly over the plants by means of a cloth sack, pepper shaker arrangement or dusting machine.

Green Arsenoid.

This is often substituted for Paris green, and may be used in the same proportion, but should never be used as a liquid spray without the addition of lime. Green arsenoid is lighter in weight, not crystalline in form, and remains in suspension longer than Paris green, but otherwise it has no advantage unless it can be purchased at less cost.

Arsenate of Lead.

Acetate of Lead *(Sugar of Lead)*	11 ounces
Arsenate of Soda	4 ounces
Water	50 gallons

This is a formula for home-made arsenate of lead, prepared by dissolving the acetate of lead in one gallon of water, and the arsenate of soda in two quarts of water in a separate vessel. It is best to use wooden buckets. When the two solutions are poured together a fine, white precipitate is formed. This makes a stock solution ready to dilute with 50 gallons of water.

The advantages of arsenate of lead over Paris green and green arsenoid are: (1) greater adhesive quality; (2) remains in suspension with very little agitation; and (3) seldoms injures foliage. It is generally claimed that it will not burn or injure the tenderest foliage, but this is not true, although it is perfectly safe to use on most garden vegetables.

Arsenate of lead is now manufactured rather extensively and is put up and sold as a dry powder or paste. At wholesale prices the manufactured product is about as cheap as that prepared at home, and somewhat preferable, because of its always being ready to mix with water.

Bordeaux Mixture and Arsenicals.

Bordeaux mixture	50 gallons

Containing one of the following:

Paris Green	1-3 to 1-2 pound
Arsenate of Lead	3 pounds
Green Arsenoid	1-3 to 1-2 pound

It is frequently desirable to use arsenicals in Bordeaux mixture because, in addition to killing the insects, the plants should be protected from leaf diseases. Bordeaux mixture is a great help towards keeping plants healthy. Furthermore, the poison is made to adhere longer, and is very much less liable to injure the foliage when used in this manner.

Bordeaux Mixture.

Bluestone (Copper Sulphate)	4 pounds
Lime, fresh unslaked	6 pounds
Water	50 gallons

To prepare.—Dissolve the bluestone in 25 gallons of water in one receptacle, and slake the lime in another, and dilute to 25 gallons. Do not pour the solutions directly together, but take a bucketful of each and pour these simultaneously into a barrel or spray tank. As the solutions unite a fine blue precipitate is obtained, and the resulting mixture will not settle as rapidly as when the two solutions are mixed by pouring one directly into the other.

Many writers advocate making Bordeaux for general use with 6 pounds of bluestone and 6 pounds lime, but this is apparently stronger than is necessary, and at the present price of bluestone, is rather expensive.

Adhesive Resin Wash.

With a few plants, like cabbages and collards, which have very smooth foliage, difficulty is often experienced in making poison mixtures adhere. To overcome this difficulty, the following is suggested:

Stock Solution	Pulverized Resin	5 pounds
	Concentrated Lye	1 pound
	Fish Oil	1 pint
	Water	5 gallons

To prepare.—Place the oil and resin in one gallon of water and boil until the resin is thoroughly softened. Dissolve the lye in a separate vessel and add slowly to the resin mixture, stirring constantly until well mixed. Then add four gallons of water and continue the boiling until the resulting mixture will mix readily with cold water.

DIRECTIONS FOR USING.

Resin Mixture *(Stock Solution)*	1 gallon
Water	16 gallons
Milk of Lime (2 pounds unslaked lime)	3 gallons
Paris Green or Green Arsenoid	1-4 pound

To prepare.—Add water to the stock solution and mix thoroughly; then add the milk of lime, and then the Paris green or green arsenoid. The order of mixing should not be changed, or a heavy precipitate will form that will clog the spray pump and nozzle. The stock solution may be kept on hand, but the diluted mixture must be freshly prepared when used.

Hellebore.

Hellebore acts both as an internal and contact poison. It is used against soft-bodied caterpillars, such as cabbage worms, in liquid form, 1 ounce in 3 gallons of water; or mixed, dry, with four parts of cheap flour or road dust. It loses its strength when exposed and must be applied every two or three days as long as the worms are present. This is not very valuable for use except on vegetables that are nearly grown.

FOR SUCKING INSECTS.

Kerosene Emulsion.

Stock Solution.	Hard Soap	1-2 pound
	Or Soft Soap	1 quart
	Water	1 gallon
	Kerosene	2 gallons

To Prepare.—Dissolve the soap in one gallon of boiling water. Remove from the fire and add two gallons of kerosene and agitate the mixture violently for fully ten minutes. As the kerosene and soap solutions combine, a smooth, creamy emulsion will result, and when properly mixed, will remain for weeks without separating. The emulsion is best prepared by using a small force pump, throwing a small stream and pumping the mixture back into itself for ten minutes. Soft water should be secured, but a little common lye may be used to "soften" water that is naturally too hard.

For convenient reference the proper amount of water used in diluting the stock solution to a certain strength is given below:

For 5 per cent emulsion dilute with 37 gallons of water.
For 10 per cent emulsion dilute with 17 gallons of water.
For 15 per cent emulsion dilute with 10 1-3 gallons of water.
For 20 per cent emulsion dilute with 7 gallons of water.

Tobacco Products (as a liquid spray).

Tobacco leaves or stems	2 pounds
Water	4 gallons

Boil for about 2 hours.

Tobacco water, made by the above formula, should be used at full strength. It is valuable for killing plant lice, and as a repellent against flea beetles, cucumber beetles, etc.

Tobacco Products (in dry form).

Tobacco dust is of some value as a repellent when applied liberally to the foliage of small garden plants.

Soap Solutions.

Whale oil soap, made from refuse fish oil, is a valuable contact poison for killing plant lice. The potash soaps are preferable to soda soaps. Common potash (washing or laundry) soap may be used with success at a strength of 1 pound in 3 or 4 gallons of water, and is just as effective against common garden plant lice as whale oil soap or dilute kerosene emulsion. This gives a little better result than tobacco water.

Pyrethrum.

Pyrethrum, also known as Buhach, Dalmation powder, and Persian Insect Powder, is poisonous to most insects, but harmless to higher animals. The powder gets into the breathing pores, acting by its suffocating effects, and it also contains an essential oil that kills by contact. As this oil evaporates rapidly when exposed to the air, pyrethrum must be kept in air-tight receptacles until used. Pyrethrum kept in open boxes or loose drawers is very nearly worthless.

Pyrethrum in dry form is used pure or diluted with flour, and will kill cabbage worms and most soft-bodied insects. It must be applied every two days while the insects are numerous.

Pyrethrum in solution is used by mixing 1 ounce in 2 gallons of water. In this form it will not injure the tenderest foliage.

Tobacco Fumigating Papers.

As stated on p. 41 tobacco fumigating papers have been carefully tested in Texas as a remedy for lice on cucumbers, cantaloupes, etc. The brands that have been well tested are Nico-fume Paper, To-bakine and Aphis Punk.

These papers are prepared so that they will burn rapidly and are generally lighted in tin cans under the fumigating frames, which are described on p. 41. Old tin cans with perforations near the bottom edge answer the purpose very well. The actual time required to kill the lice will vary, but may be easily determined by experience.

SPRAY PUMPS AND EQUIPMENT.

There are many forms of spray pumps on the market, some good, and some almost worthless for the purpose of spraying garden plants. Good, serviceable spray pumps fitted with suitable hose, extension rod, and nozzle, are quite necessary for the proper application of some materials recommended against garden insects. Readers who desire information on the subject of spray pumps and equipment should send for Bulletin 193 of the North Carolina Experiment Station, and should also write to a number of spray pump manufacturers for catalogues. Persons who have never used spray pumps will do well to investigate the merits of the different makes before making a purchase. The names of Spray Pump Concerns are listed in the Bulletin mentioned above.

Bulletin 198 June, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

HANDLING AND MARKETING OF MILK AND CREAM

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

Governor R. B. Glenn, *ex officio* Chairman, Raleigh

R. H. Ricks	Rocky Mount	J. T. Ellington	Smithfield
W. D. Turner	Statesville	W. E. Daniel	Weldon
O. M. Garder	Shelby	W. H. Ragan	High Point
Locke Craig	Asheville	W. B. Cooper	Wilmington
C. W. Gold	Raleigh	M. B. Stickley	Concord
E. M. Koonce	Jacksonville	T. T. Ballinger	Tryon
T. W. Blount	Roper	N. B. Broughton	Raleigh
D. A. Tompkins	Charlotte	O. L. Clark	Clarkton

STATION STAFF

George T. Winston, President of the College.

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
William Kerr	Assistant in Field Experiments
W. A. Syme	Assistant Chemist
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant in Farm Crops
J. C. Temple	Assistant Chemist and Assistant Bacteriologist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

TABLE OF CONTENTS

PAGE

A Comparison of Cream Shipping Cans........ 4

Effect of Temperature on the Keeping Quality of Milk........ 7

Milk Deliveries 11

Acidity of Fresh Milk........ 12

A Cheap but Effective Ice Box........ 12

A Cheap and Efficient Sterilizer........ 14

An Efficient Milk and Cream Cooler........ 17

Ground Plans for Dairy Houses........ 19

Sanitary Milk Production........ 20

Necessity for Thorough Cooling........ 22

Relative Market Value of Milk, Cream and Butter........ 22

Standardization of Milk and Cream........ 23

The Cream Separator........ 24

HANDLING AND MARKETING OF MILK AND CREAM.

BY JOHN MICHELS, DAIRY HUSBANDMAN.

The investigations herein reported were undertaken with a view to aiding in the improvement and extension of the milk and cream industry in North Carolina. At present, the necessity for refrigeration and cleanliness is not sufficiently appreciated by most dairymen. Investigation shows that a large percentage of the milk retailed in the larger towns and cities is neither cooled nor aerated, a fact which causes much hardship and financial loss to the dairymen of the State.

Lack of thorough cooling necessitates two deliveries of milk per day, and, what is still worse, requires dairymen to milk their cows shortly after midnight and shortly after midday, a drudgery which casts a damper upon the whole milk business. Lack of cooling also means financial loss through souring of milk and leads to many dissatisfied customers. Suitable methods for cooling milk and cream, as well as plans designed by us for the construction of simple and cheap ice boxes and sterilizers for both large and small dairymen, are fully described and illustrated in these pages.

The cream industry of the State is still in its infancy and scarcely any attempt has been made at shipping this product, though this could be made profitable. Neglect of the development of this industry by our own people has led to its monopolization by dairymen of other States. We face the deplorable fact that several of the leading markets in this State are largely supplied by cream shipped from the State of New York.

Conspicuous among other things is the need of more and better dairy houses on dairy farms, and two ground plans of such houses have been prepared, which it is hoped will stimulate much needed improvement along this line.

Many points of general information, without which a milk and cream business can not be successfully conducted, have also been incorporated.

A COMPARISON OF CREAM SHIPPING CANS.

The object of making this comparison was to determine the relative efficiency of different types of cans in maintaining low temperatures. Four leading styles of cans were used: (1) an insulated metallic can; (2) an insulated wood jacketed can; (3) an ordinary ten-gallon milk can with felt jacket around it; and (4) an ordinary ten-gallon can placed inside of a covered ice-cream shipping tub. An ordinary ten-gallon can was used as a control. (See Figs. 1, 2, 3, 4, 5.)

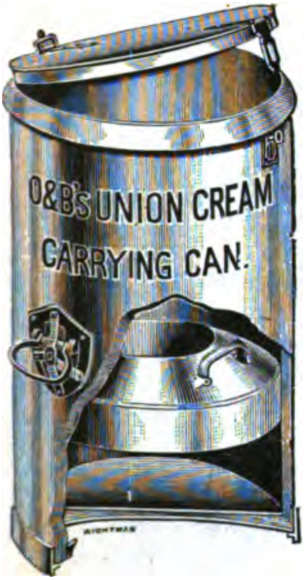


FIG. 1.—Insulated Metalic Can.

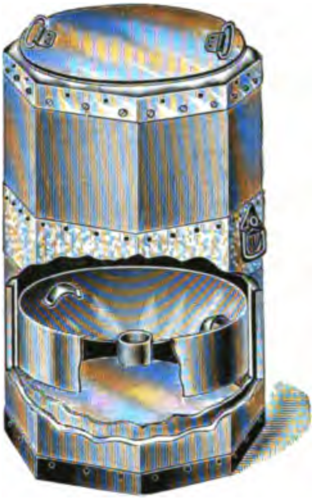


FIG. 2—Insulated Wood Jacketed Can.

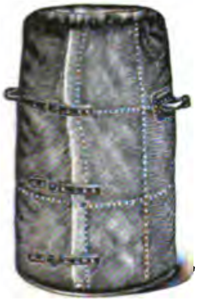


FIG. 3—Felt Jacketed Can.

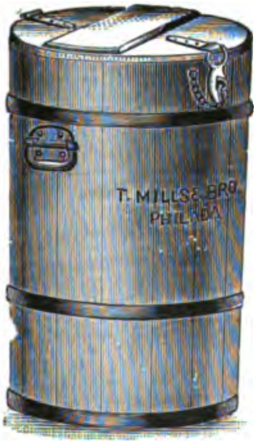


FIG. 4—Ice-cream Shipping Tub.

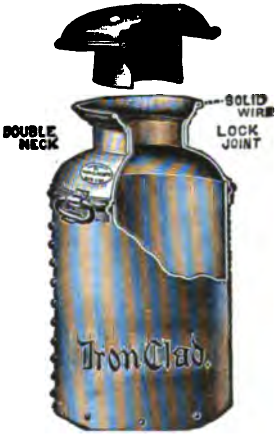


FIG. 5—Ordinary Milk Can.

In all the experiments, ten gallons of water was used in each can, and all cans were of ten gallons capacity, except the insulated metallic can, and the insulated wood jacketed can, which had a capacity each of twenty gallons. The initial temperature of the water in all cans was 45° F. in each experiment.

The relative rise of temperature at intervals up to twenty-four hours, as well as the room temperature to which the cans were exposed, are shown in the following table:

TABLE I.—SHOWING RELATIVE EFFICIENCY OF CANS IN HOLDING TEMPERATURE.[1]

Number of Experiment.	Number Hours after Cooling to 45° F.	Room Temperature.	Temperature.					
			Ordinary Milk Can.	Insulated Metallic Can.	Insulated Wood Jacketed Can.	Ordinary Milk Can Covered With Felt Jacket.	Ordinary Milk Can in Covered Wooden Tub.	Pounds Ice Used in Wooden Tub.
1	3	78	50	48	48	47	42	8
	6	73	52	49	49	48	40	
	9	70	56	52	52	50	42	
	24	71	60	57	57	56	52	
2	3	78	52	49	49	49	40	38[2]
	6	79	57	50	51	51	36	
	9	79	59	54	55	54	34	
	24	66	58	55	56	54	32	
3	3	79	50	48	48	48	38	8
	6	81	55	50	50	50	34	
	9	79	60	52	52	54	35	
	24	70	62	57	57	56	43	
4	3	74	50	48	48	48	48	None.
	6	74	54	50	51	50	50	
	9	72	56	51	52	51	52	
	24	70	60	56	56	56	56	
5	3	83	54	48	49	48	42	15
	6	84	61	52	58	52	40	
	9	78	64	54	55	54	41	
	24	77	67	59	60	59	52	
6	3	80	57	48	48	47	48	None.
	6	80	55	51	50	50	51	
	9	74	58	52	52	51	52	
	24	75	60	58	58	57	57	
7	3	83	54	48	48	48	42	20
	6	85	59	52	52	51	39	
	9	80	62	54	54	58	36	
	24	81	66	61	62	61	45	

[1] Ice used was broken into pieces about the size of two fists.
[2] Ice size of nut coal.

Table I shows that so far as maintaining temperature is concerned, there is practically no difference in the insulated metallic, insulated wood jacketed, and felt jacketed cans. It is clear, however, that where low temperatures are to be maintained for nine or more hours during warm weather, the covered wooden tub, which allows ice to be packed around the can, is the most satisfactory. The ice should be left coarse, and should be packed around the neck of the can. The amount needed will vary of course with the temperature of the atmosphere, and the length of time the cream is in transit. The wooden tub without ice has practically the same insulating effect as the felt jacket.

EFFECT OF TEMPERATURE ON THE KEEPING QUALITY OF MILK.

The bulk of milk produced in this State is sold to consumers without any cooling whatever; hence the prevailing practice of delivering the morning milk in time for breakfast, and the evening milk in time for supper. This practice, aside from necessitating two deliveries a day and resulting in much sour milk, requires the first milking of the day to be done shortly after midnight, and the second milking shortly after midday.

Few dairymen are willing to undertake dairying when the milking must be done at these hours. Certainly none could do so with any degree of pleasure. All this drudgery of night and day work can largely be obviated by thoroughly cooling the milk as soon as possible after milking, which will prolong its keeping quality. This is clearly shown in the following table, in which the night milk was cooled to 45° F., one hour after milking, and then placed in the refrigerator. The milk of the following morning was also cooled to 45° F., one hour after milking, after which it was placed at room temperature, simultaneously with the milk of the previous night, which had been held in the refrigerator. Both samples of milk were tested for acidity three times a day with the results recorded in Table II. With these and all other samples acid determinations were made by using one-tenth normal sodium hydroxide with phenolphthalein as indicator.

To those unacquainted with milk acid tests, it should be stated that milk is still perfectly sweet when it shows 0.25 per cent acid, and that the first signs of "turning" or souring are usually detected when the acidity reaches 0.30 per cent.

TABLE II.—Showing Acidity of Milk at Different Ages.

Number of Experiment.		Acidity of Milk—Percent.				
		5.00 [1] p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
1	Night milk	0.167	0.180	0.185	0.190	0.306
	Morning milk		0.176	0.189	0.194	0.311
	Room temperature	43	74	82	81	82
2	Night milk	0.169	0.181	0.185	0.208	0.297
	Morning milk		0.180	0.189	0.212	0.313
	Room temperature	45	74	88	78	70
3	Night milk	0.176	0.188	0.189	0.194	0.237
	Morning milk		0.180	0.187	0.208	0.246
	Room temperature	45	70	75	77	64
4	Night milk	0.174	0.188	0.198	0.205	0.221
	Morning milk		0.176	0.199	0.208	0.225
	Room temperature	43	60	72	70	59
5	Night milk	0.168	0.180	0.188	0.201	0.226
	Morning milk		0.188	0.189	0.201	0.228
	Room temperature	45	70	72	71	60
6	Night milk	0.174	0.181	0.198	0.206	0.221
	Morning milk		0.187	0.207	0.212	0.234
	Room temperature	43	69	70	75	68
7	Night milk	0.194	0.201	0.217	0.230	0.257
	Morning milk		0.208	0.216	0.230	0.237
	Room temperature	43	71	79	73	73
8	Night milk	0.205	0.216	0.230	0.285	0.512
	Morning milk		0.205	0.221	0.228	0.357
	Room temperature	45	78	78	78	72
9	Night milk	0.210	0.218	0.234	0.241	0.378
	Morning milk		0.212	0.219	0.225	0.300
	Room temperature	44	72	76	77	72
10	Night milk	0.210	0.216	0.226	0.241	0.594
	Morning milk		0.205	0.223	0.230	0.510
	Room temperature	45	72	84	78	82

TABLE II—Continued.

Number of Experiment.		Acidity of Milk—Per cent.				
		5.00[1] p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
11	Night milk	0.208	0.204	0.219	0.225	0.318
	Morning milk		0.216	0.230	0.237	0.360
	Room temperature	45	75	80	80	76
12	Night milk	0.198	0.205	0.212	0.221	0.467
	Morning milk		0.210	0.221	0.228	0.709
	Room temperature	45	76	75	77	74
13	Night milk	0.217	0.232	0.237	0.266	0.700
	Morning milk		0.210	0.223	0.246	0.278
	Room temperature	46	82	92	82	75

[1] Temperature readings in this column were made in the refrigerator.

The results show that there is only a very slight development of acidity in milk which was kept at temperatures ranging between 43° and 45° F. They also show that night milk kept at these temperatures until the following morning (15 hours) and then placed at room temperature will keep sweet fully as long after being placed at this temperature as does the morning milk placed at the same room temperature immediately after cooling to 45° F. Table II further shows that night milk cooled to 45° F. and then kept at refrigerator temperature (43° F.) for 15 hours, will be sweet at the end of 24 hours, even when kept during the last nine hours at room temperature ranging from 82° to 92° F.

The results given in the following table were secured by cooling the morning milk to 45° F. one hour after milking, and then keeping it in the refrigerator for 24 hours. The night milk of the same day was cooled to 45° F., one hour after milking, and then placed in the refrigerator 15 hours, or until eight o'clock next morning, when it, together with the milk of the preceding morning, was placed at room temperature.

TABLE III.—Showing Acidity of Milk at Different Ages.

Number of Experiment.		Acidity of Milk—Percent.					
		8.00 a.m.	5.00 p.m.	8.00 a.m.	12.00 noon.	5.00 p m.	8.00 a.m.
1	Morning milk	0.194	0.198	0.201	0.216	0.219	0.241
	Night milk		0.170	0.205	0.219	0.230	0.507
	Room temperature			76	80	84	70
	Refrigerator temperature	45	40	42			
2	Morning milk	0.18	0.212	0.223	0.237	0.248	0.261
	Night milk		0.176	0.198	0.234	0.241	0.252
	Room temperature			86	84	76	84
	Refrigerator temperature	45	45	44			
3	Morning milk	0.187	0.201	0.212	0.219	0.230	0.518
	Night milk		0.187	0.198	0.201	0.221	0.313
	Room temperature			76	88	93	77
	Refrigerator temperature	45	40	41			
4	Morning milk	0.183	0.194	0.208	0.219	0.230	0.657
	Night milk		0.190	0.212	0.221	0.232	0.856
	Room temperature			79	85	95	78
	Refrigerator temperature	42	46	44			
5	Morning milk	0.187	0.212	0.217	0.226	0.234	0.248
	Night milk		0.187	0.216	0.223	0.241	0.252
	Room temperature			65	80	76	73
	Refrigerator temperature	45	42	41			
6	Morning milk	0.176	0.187	0.194	0.201	0.216	0.236
	Night milk		0.180	0.190	0.210	0.234	0.334
	Room temperature			73	86	89	76
	Refrigerator temperature	45	45	44			
7	Morning milk	0.198	0.205	0.214	0.221	0.228	0.252
	Night milk		0.194	0.216	0.223	0.228	0.248
	Room temperature			78	87	92	73
	Refrigerator temperature	44	43	44			
8	Morning milk	0.208	0.214	0.220	0.228	0.235	0.360
	Night milk		0.210	0.212	0.226	0.237	0.370
	Room temperature			78	84	86	80
	Refrigerator temperature	44	46	46			

TABLE III.—Continued.

Number of Experiment.		Acidity of Milk—Percent.					
		8.00 a. m.	5.00 p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
9	Morning milk	0.208	0.219	0.223	0.235	0.235	0.306
	Night milk		0.214	0.216	0.219	0.221	0.300
	Room temperature			80	89	89	71
	Refrigerator temperature	46	44	43			
10	Morning milk	0.210	0.216	0.223	0.226	0.237	0.252
	Night milk		0.194	0.199	0.214	0.230	0.237
	Room temperature			71	70	73	73
	Refrigerator temperature	43	43	41			

This table, like the preceding, shows that there is but slight acid development in milk kept at refrigerator temperatures ranging from 42° to 45° F. The morning milk kept at these temperatures showed an average increase of acidity of only 0.05 per cent during twenty-four hours. These results also show that morning milk, after being kept at 42° to 45° F. for twenty-four hours, and then placed at high room temperatures is still perfectly sweet at the end of thirty-three hours.

MILK DELIVERIES.

The facts brought out in connection with our cooling experiments clearly show that the time of the delivery of milk may be made entirely independent of the time of milking. When milk is cooled to 45° F. and kept at this temperature, the night milk may be delivered the following morning, either in time for breakfast or after. The morning milk may be kept in the refrigerator till after dinner and delivered before supper. Of course the milk will be fresher and sweeter for the consumer when the night milk is delivered before breakfast, so that the morning milk need not be kept over night by the consumer.

Upon our advice, this latter plan of delivery has been adopted by a local dairyman, who, like the vast majority, had been in the habit of milking his cows shortly after midnight and shortly after midday and delivering his milk, without cooling, immediately after milking. The effect of the change has been a marked improvement in the quality of his milk, as is evidenced both by a marked increased demand for it as well as by a very material reduction of its bacterial content. From the middle of March to the middle of May, 1907, under the old system, the number of bacteria contained in his milk averaged 634,400 per cubic centimeter, while under the new system for the corresponding period of 1908, the number of bacteria averaged only 236,000 per cubic centimeter, a reduction of 63 per cent. This reduction in bacterial content, furthermore, was accomplished in spite of the fact that the cooled milk reached the market from six to twelve hours older than did the uncooled milk delivered under the old system. In addition, this dairyman and his milkers found the work under the new system much more agreeable, because it permitted the milking to be done at hours which suited their convenience and comfort.

With thorough cooling, it is possible to deliver both night and morning milk at the same time, preferably before dinner. Milk so delivered will be sweet the following morning, especially when kept cool in transit and in the home of the consumer.

Whatever plan of delivery is adopted, it is certain that milk thoroughly cooled and kept cool fifteen hours before delivery, will give consumers better satisfaction than milk delivered immediately after milking without cooling. Not only will the milk be of better quality but the milkman may milk his cows at his convenience, say at 5 o'clock in the morning and 4 o'clock in the afternoon, or just as he would if he were making butter.

ACIDITY OF FRESH MILK.

In Tables II and III, the first acid determination reported for both the night and morning milk was made one hour after milking. The percentage thus found in fresh milk averaged nearly 0.2 per cent, or practically double that ordinarily reported by dairy chemists.

The ration fed, while these acid determinations were being made, consisted of corn stover and corn silage as roughage, and four parts cotton-seed meal, two parts dried brewers' grains, and two parts corn meal as the concentrates. A few cows, however, received no silage, but the acidity of their milk was practically the same as that secured from silage-fed cows. The high acid-content of all these samples can not therefore be ascribed to the feeding of silage.

Some of the milk was boiled slightly to drive off any carbon dioxide which it might contain, with the result that a slightly reduced percentage of acid was found. Further studies are being made to ascertain, if possible, the cause for the presence of the unusually high percentage of acid found in the fresh milk used in these experiments.

A CHEAP AND EFFECTIVE ICE BOX.

Cold storage of some kind is indispensable to a well equipped dairy. Many, however, lack this essential, and probably largely owing to the high cost of commercial refrigerators. The construction of the ice box detailed below is the result of an attempt to give dairymen a serviceable cold storage at as low a cost as possible.

The construction of this box, shown in Fig. 6, consists essentially of two boxes separated by 1-inch strips placed at intervals of about one foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A 1-inch strip, two inches wide, covers the upper space between the 1-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

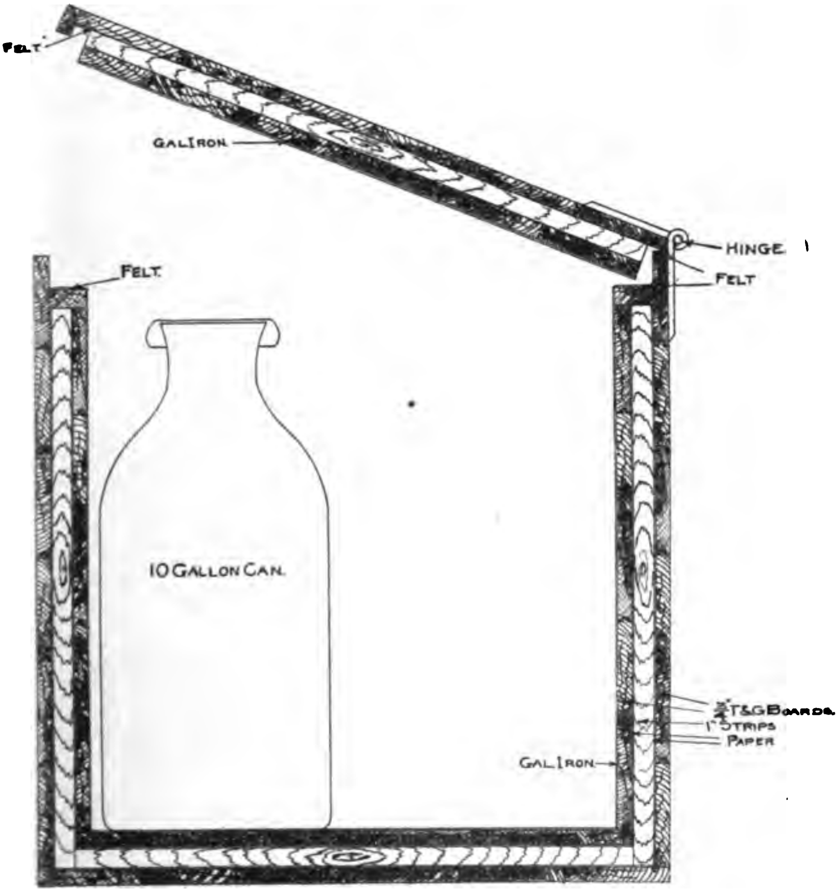


Fig. 6—Cross-section through Ice Box.

The sides, bottom and cover of the refrigerator are built of ¾-inch tongued and grooved lumber, five and a half inches wide. The ends are constructed of 1⅛-inch tongued and grooved flooring three and a half inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around the box and cover where the two meet. The four vertical edges of the refrigerator are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

A heavy weight attached to a ½-inch rope, running over a pulley fastened to the ceiling, raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the side of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of ½-inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being immersed in a cup of water to prevent entrance of air into the box.

The entire construction of the ice box is so simple that any one with a little knowledge of carpentry can readily build it.

The inside dimensions are: Length, 7 1-3 feet; width, 2½ feet; depth, 2 1-3 feet.

An itemized statement of the cost of it is as follows:

200 ft. ¾" x 5½"—16′ tongued and grooved lumber	$4.00
54 ft. 1⅛" x 3½"—16′ tongued and grooved lumber	2.16
168 ft. 1" x 1"—12′ strips	1.26
4 hinges	.60
½ yard felt	.63
15 ft. ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 sq. ft. building paper	.60
Total cost	$27.40

Commercial refrigerators of equal capacity and no greater efficiency will cost from $60.00 to $100.00, or about three times as much as the refrigerator above described.

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When twenty-two gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds. and the average temperature of the box 40° F.

A CHEAP AND EFFICIENT STERILIZER.

All vessels and appliances used in the handling of milk, cream and butter should be rendered sterile after washing, either by placing them in boiling water for about five minutes or by steaming them for an equal length of time.

Small dairies without boilers should sterilize with hot water, but the larger dairies will find it advantageous to use a steam boiler and sterilized with steam. To perform this operation efficiently, it requires a closed steam chest large enough to hold everything that is to be sterilized. Sterilizers of this type are usually constructed of concrete, or brick and concrete, and are provided with a heavy iron door, this being large enough to admit a truck bearing the pails, cans, bottles, etc. Still other sterilizers of this type are constructed of

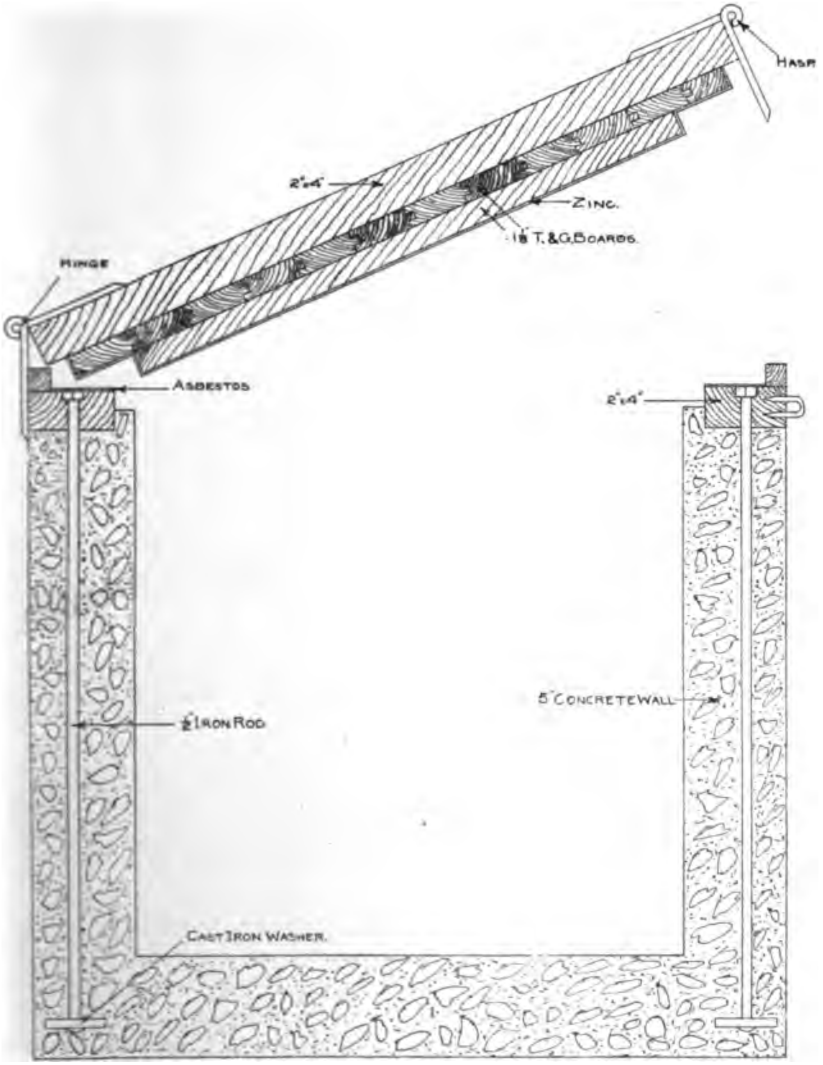


Fig. 7—Cross-section of Sterilizer.

galvanized iron or boiler plate, and all permit of sterilizing under more or less pressure.

The principal drawback to these various steam sterilizers is the high cost, which renders their use by the smaller dairymen almost prohibitive. After considerable experimentation and study, the writer has succeeded in constructing an efficient sterilizer which will cost only about one-third as much as the cheapest sterilizer of the type just mentioned. The construction of this new sterilizer, whose inside dimensions are: 7 feet long by 2¼ feet deep, by 2¼ feet wide, is very simple. (See Fig. 7.)

Essentially, it is a rectangular concrete tank with a wooden cover, which is lined with zinc. The sides and bottom are five inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2 x 4 studding is placed around the top of the tank and is secured by six ½-inch iron rods, two feet long, embedded in the concrete walls, one being placed at each corner, and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

The cover consists of two thicknesses of 1 1-8-inch tongue and grooved flooring 3½ inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2 x 4 studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2 x 4s. A safety valve, set at ten pounds pressure, is inserted through the top of the cover at the most convenient place. An outlet for condensed steam is provided at the bottom.

The cover is raised and lowered in the same manner as that of the ice box described on page 15. The cover is strengthened by running three pieces of 2 x 4 studding crosswise of the tank, one at the middle and one at either end. The hinges, by which the cover is fastened, are attached to these 2 x 4 pieces, as shown in Fig. 7.

The following is an itemized statement of the approximate cost of the material of this sterilizer when the inside dimensions are: Length, 7 1-3 feet; width, 2¼ feet; depth, 2 1-3 feet:

2	bbls. of Portland cement	$5.20
20	ft. of 2 x 4 studding	.30
110	ft. of 1⅛ tongue and grooved flooring, 3½ wide	4.40
4	hinges	.40
5	lbs. nails	.20
6	½-inch iron rods 2½ feet long	1.20
3	hasps	.30
20	sq. ft. zinc	1.75
	Ball and lever safety-valve	1.00
3	pounds sheet asbestos	.30
	Total	$15.05

EFFICIENT MILK AND CREAM COOLER.

After a careful test of different cooling devices, it has been found that for dairies having twenty or more cows the cooling arrangement shown in Fig. 8 is the best thus far tried. This flat, corrugated cooler consists of two parts: an upper section, which is used for cooling milk or cream with uniced water, and a lower section, through which ice water is circulated. By means of the pump at the left, the ice water is pumped back in the tin can at the right, which contains the ice. The well water is admitted to the upper section of the cooler by opening the valve shown at the upper right-hand corner of the cooler. On a farm, a barrel or tank elevated to the height of this valve could be used as a water storage from which water may be drawn into the upper section of the cooler. The water in both sections enters at the bottom between the two corrugated surfaces and discharges at the top, the milk flowing over the outside.

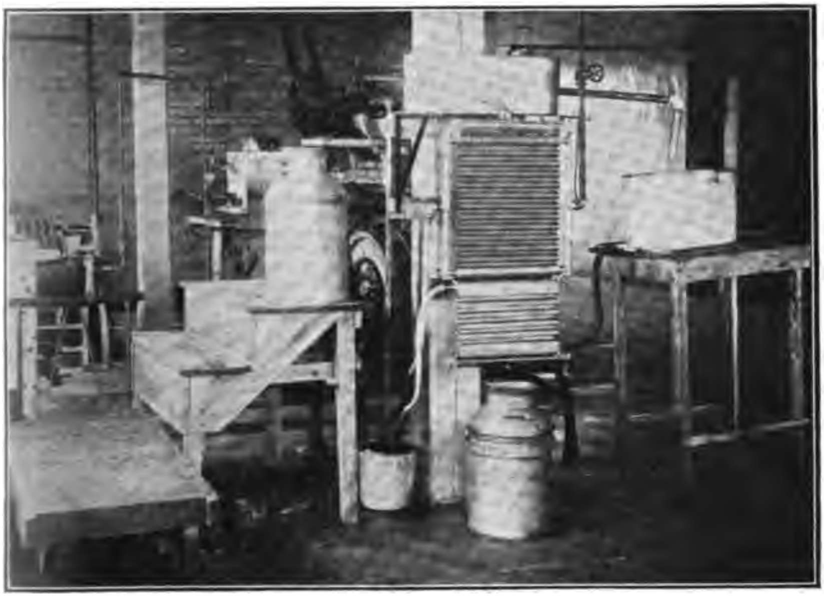


Fig. 8—Milk and Cream Cooler.

As might be expected, by forcing the ice water from the cooler back into the ice water storage, a considerable saving is effected, not only of ice and water, but of time as well. Proof of these advantages is brought out by the results recorded in the following table, which shows the work of the cooler with and without the ice water pump. When no pump was used, ordinary well water was sprayed over finely crushed ice in the can shown at the right, and the discharge was allowed to run into the drain.

All the milk was cooled to 45° F., and the amount of milk cooled in each experiment was eighty-four gallons, one-half of which was cooled with a pump and the other half without:

TABLE IV.—SHOWING WORK OF COOLER WITH AND WITHOUT THE PUMP.

Number of Experiment.		Amount Ice Used—Pounds.	Time in Cooling—Minutes.	Temperature of Milk Before Cooling—Degrees F.	Temperature of Well Water—Degrees F.
No. 1	With pump	37	45	85	73
	Without pump	89	92	88	73
No. 2	With pump	35	40	85	66
	Without pump	94	82	84	66
No. 3	With pump	32	35	82	64
	Without pump	85	93	85	64
No. 4	With pump	38	45	88	72
	Without pump	95	85	85	72
No. 5	With pump	34	43	85	70
	Without pump	83	88	88	70
Average	With pump	35	41	85	69
	Without pump	89	88	86	69

For smaller dairies, a cheap cooler like that shown in Fig. 9 may be used to advantage. The water enters the bottom of the cooler and discharges at the top, the milk flowing in a thin sheet over the outside. Ice may be placed inside of the cooler.

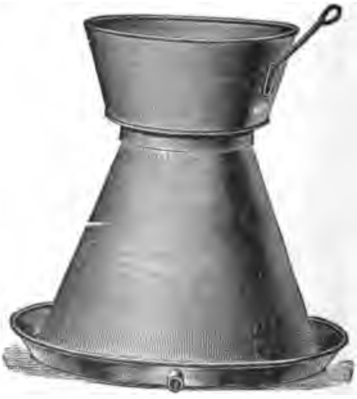


Fig. 9—Milk and Cream Cooler.

GROUND PLAN FOR DAIRY HOUSES.

Two satisfactory ground plans for dairy houses are shown in Figs. 10 and 11.

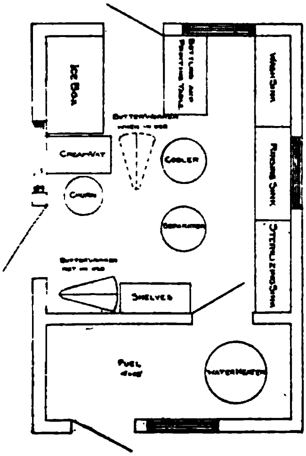


Fig. 10—Ground Plan for Dairy House for 10 to 20 Cows.

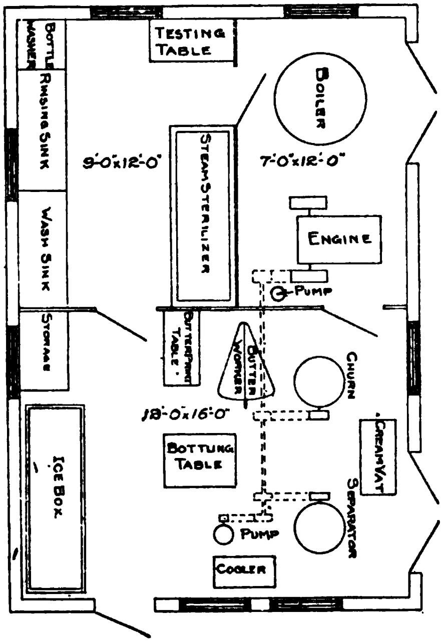


Fig. 11—Ground Plan for Dairy House for 20 to 50 Cows.

(Interchange position of cooler and bottling table in Fig, 11.)

The dimensions of the smaller dairy house are 10′ x 16′, and those of the larger 16′ x 24′.

GENERAL INFORMATION.

Many cities in North Carolina are suffering from a shortage of milk and cream, in spite of the remunerative prices which are offered for these products. This, no doubt, is largely due to the fact that dairymen remotely situated from cities, believe that distance must necessarily deprive them of city markets. It is certain at any rate that scarcely any effort is being made by these dairymen to cater to city trade. Enquiry shows that shipment of cream and milk by rail has scarcely been attempted in this State. Yet that this can be successfully done is amply proven by our own experience and by the fact that a large portion of the cream used in the State is sent in from other States.

To make milk and cream shipment a success, however, it is necessary to understand the correct handling of the milk from the time it leaves the cow until it reaches the city dealer. The brief discussion which follows is intended to supply this information.

SANITARY MILK PRODUCTION.

The first and most important essential in building up a successful cream and milk business is cleanliness. Milk produced and handled under filthy conditions is dangerous to the health of adults and is one of the chief causes of the high mortality among infants. A large proportion of the consumers in cities is conscious of these dangers, and will pay almost any price for milk and cream that are known to be clean and wholesome. The conditions necessary for the production of a high class of milk are discussed in the following paragraphs:

HEALTHY COWS.—The health of the cow is of prime importance in the production of sanitary milk. All milk from cows affected with disease of any kind should be discarded. Aside from the general unfitness of such milk, there is danger of disease producing organisms getting into the milk. It has been found, for example, that cows whose udders are affected with tuberculosis, yield milk containing the germs of this disease. Even where the udder is not affected, there is great danger of infecting the milk with tubercle germs, because these germs are frequently found in the dung of tuberculous cows. The prevalence of this disease among cows makes it imperative to determine definitely whether or not cows are affected with it.

CLEAN COWS.—The source of most of the dirt commonly found in milk is the cow; hence the importance of keeping her thoroughly clean. This requires clean dry barns and barnyards, daily carding of the cows, and washing of the udder before milking. A covered pail like that shown in Fig. 12 reduces contamination to a great extent.

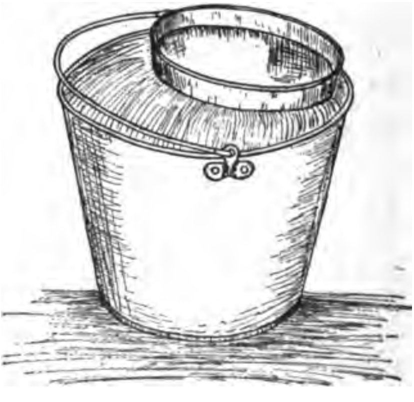


Fig. 12—Covered Milk Pail.

Sterile Milk Vessels.—All vessels used in the handling of milk and cream should be made of good tin, with as few seams as possible. Wherever seams occur, they should be flushed with solder. Unflushed seams are difficult to clean and afford good breeding places for bacteria. It is very important to clean and sterilize all milk vessels as soon as possible after use. This is satisfactorily accomplished as follows:

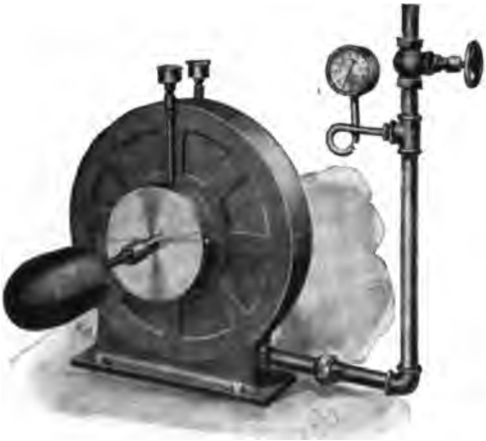


Fig. 13—Bottle Washer.

First, rinse with warm or cold water, which should be followed by scrubbing with moderately hot water containing some alkali, like sal soda. The washing should be done with brushes rather than cloths, because the bristles enter into crevices which the cloth could not possibly reach. Next scald thoroughly with steam or hot water after rinsing in clean water. After scalding, the utensils should be inverted on shelves without wiping and allowed to remain until ready for use. If possible, turn the inside of the vessel to the direct rays of the sun in a place where there is no dust. The best place in which to leave the vessels is a covered sterilizer.

Clean Milkers.—No diseased or convalescent person should come in contact with the cows. At milking time, clean milking suits should take the place of those worn in the fields, and the milkers should wash their hands thoroughly just before milking. The filthy practice of milking with wet hands can not be too strongly condemned, since it is just as easy, if not more so, to milk with dry hands. Where the milker wets his hands with milk, some of it is bound to drop into the pail, carrying with it thousands or even millions of bacteria.

CLEAN, WHOLESOME FEED AND WATER.—Highly fermented and aromatic feeds like sour brewers' or distillery grains and wild onions when eaten by the cows, are certain to produce bad flavored milk. The same may be said of impure or stagnant water.

DUST FREE AIR.—Great precaution should be taken not to raise any dust in the stable about milking time, for some of this will be certain to find its way into the milk. Cows should therefore never be bedded or given dusty feed just before or during milking.

STRAINING MILK.—Milk should be drawn so clean as to make it almost unnecessary to strain it. This operation is frequently done under the illusion that so long as it removes all visible dirt the milk has been entirely purified. The real harm, however, that comes from hairs and dust particles dropping into the milk is not so much in the hairs and dust particles themselves as in the millions of bacteria which they carry with them. These bacteria are so small that no method of straining will remove them. Straining can not even remove all of the dirt, because some of it will go in solution.

A good strainer consists of two thicknesses of cheese cloth with a layer of absorbent cotton between. The strainer is to be placed on the can or vat into which the milk is to be strained and not on the milk pail.

FLIES.—Flies not only constitute a prolific but also a dangerous source of milk contamination. These pests visit places of the worst description and their presence in a dairy suggests a disregard for cleanliness. Of 414 flies examined by the Bacteriologist of the Connecticut Station, the average number of bacteria carried per fly was *one and a quarter millions.*

NECESSITY FOR THOROUGH COOLING.

Next to cleanliness, a low temperature is of the greatest importance in marketing milk and cream. The temperature should be reduced to 45° F. or below as soon as possible after milking. This requires special coolers like those shown in Figs. 8 and 9. Cooling not only materially prolongs the keeping quality of milk, but also improves its flavor. Milk, no matter how clean, will have a more or less stifled odor if bottled without cooling.

If the milk or cream is to be held any length of time after cooling, it should be put into an ice box similar to the one described on page 13.

RELATIVE MARKET VALUE OF MILK, CREAM AND BUTTER.

Whether it pays best to sell milk, cream or butter depends largely upon the market prices for these products. In North Carolina these prices will average about as follows: butter, 25 cents per pound;

milk, 8 cents per quart; and cream, testing 20 per cent butter fat, $1.00 per gallon. Accepting these as average prices, let us determine the relative returns from one hundred pounds of milk containing 4 per cent butter fat, when (1) retailed by the quart; (2) when sold as cream; and (3) when made into butter.

One hundred pounds of 4 per cent milk is equal to 46.5 quarts (a quart of milk weighs 2.15 pounds), which at 8 cents per quart is worth $3.72.

One hundred pounds of 4 per cent milk will make 2.5 gallons of cream testing 20 per cent fat, as determined by the following formula:

$$X = \frac{(A \times B)}{C}, \text{ in which}$$

X = Number pounds of cream
A = Number pounds of milk
B = Test of milk
C = Test of cream
Substituting we get,

$$X = \frac{(100 \times 4)}{20} = 20, \text{ the number of pounds of cream.}$$

At 8 pounds to the gallon the 20 pounds of cream will be equal to 2.5 gallons which, at $1.00 per gallon, will bring $2.50. Allowing 1 cent per pound for the skim milk, we have 80 cents as the selling price of skim milk, which, when added to the $2.50, gives a total value of $3.30 for each hundred pounds of milk.

One hundred pounds of 4 per cent milk will yield 4 2-3 pounds of butter, because where up-to-date methods of creaming and churning are followed every pound of butterfat will make 1 1-6 pounds of butter. Four and two-third pounds of butter at 25 cents per pound are worth $1.17. Valuing buttermilk at the same price as skim milk (1 cent per pound), 95 cents should be added to the $1.17 as the value of the skim milk and buttermilk, which makes a total value of $2.12.

The preceding calculation shows that at the prices given, 100 pounds of 4 per cent milk is worth $3.72 when retailed by the quart; $3.30 when sold as cream in bulk; and $2.20 when made into butter. Since selling the cream in bulk requires much less labor than retailing milk by the quart, and since cream also sours less quickly than milk, there is no question whatever that it is more profitable to sell cream than milk. It is also evident that it pays better to retail milk, where this is possible, than to make butter.

STANDARDIZING CREAM AND MILK.

This is a process by which milk and cream are brought to a definite percentage of fat. For example, one customer may want cream testing 30 per cent fat, another may prefer 20 per cent and still another may want 40 per cent, and so on. While the cream separator may be regulated to give cream of any desired richness, there will necessarily be some variation in the percentage of fat from day to day, so there must be devised some way of getting cream to test the same every day. This is best accomplished by producing cream somewhat above the richness desired and then reducing the same to the required richness by the addition of skim milk. The amount of skim milk to be added is determined from the following formula:

$$X = \frac{(A \times B)}{C} - A, \text{ in which}$$

X = Number pounds of skim milk to be added
A = Number pounds of original cream
B = Test of original cream
C = Test desired.

Problem.—How many pounds of skim milk must be added to 70 pounds of cream testing 44 per cent to reduce the test to 20 per cent? Applying the formula we get—

$$X = \frac{(70 \times 44)}{20} - 70 = 84 \text{ pounds.}$$

This formula may also be used in standardizing milk.

THE CREAM SEPARATOR.

Dairies having four or more cows should cream their milk with a centrifugal machine, a hand separator. The saving of butter fat by the use of this method will soon pay for the cost of the separator. Moreover, this method has additional advantages over the common gravity or shallow pan method of creaming, in that it provides fresh, sweet cream of any desired richness as well as furnishing sweet skim milk for feeding purposes. The man who sells cream should provide himself with a centrifugal cream separator.

That the owner of four good cows can afford to invest $50.00 in a small cream separator that would answer for this number of cows, is shown by the following: Four good cows will yield not less than 24,000 pounds of milk a year. By the common shallow pan method of creaming, the loss of butter fat will average 0.7 pound for every 100 pounds of milk. With the centrifugal separator the loss of fat will not average over 0.05 pound, hence there will be effected a saving of 0.65 pound of butter fat in each 100 pounds of milk by the use of the separator. At this rate, the total saving of butter fat annually on the 24,000 pounds of milk will be 156 pounds. Since each pound of butter fat will yield approximately 1 1-6 pounds of butter, 183 pounds of butter will be saved by the process, which taken at 25 cents per pound amounts to a difference of $45.75. This saving in butter fat alone will almost pay for the separator in one year.

Bulletin 199 June, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

FEEDING EXPERIMENTS WITH COWS AND CALVES

I. COMPARISON OF COTTON-SEED HULLS AND SHREDDED CORN STOVER FOR MILK PRODUCTION

II. CORN MEAL VERSUS A MIXTURE OF CORN MEAL AND DRIED BREWERS' GRAINS AS A SUPPLEMENT TO COTTON-SEED MEAL FOR MILK PRODUCTION

III. ROLLED OATS AS A PARTIAL SUBSTITUTE FOR MILK IN CALF FEEDING

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

Governor R. B. Glenn, *ex officio* Chairman, Raleigh

R. H. Ricks	Rocky Mount	J. T. Ellington	Smithfield
W. D. Turner	Statesville	W. E. Daniel	Weldon
O. M. Gardner	Shelby	W. H. Ragan	High Point
Locke Craig	Asheville	W. B. Cooper	Wilmington
C. W. Gold	Raleigh	M. B. Stickley	Concord
E. M. Koonce	Jacksonville	T. T. Ballenger	Tryon
T. W. Blount	Roper	N. B. Broughton	Raleigh
D. A. Tompkins	Charlotte	O. L. Clark	Clarkton

STATION STAFF

George T. Winston, President of the College.

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
William Kerr	Assistant in Field Experiments
W. A. Syme	Assistant Chemist
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant in Farm Crops
J. C. Temple	Assistant Bacteriologist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

TABLE OF CONTENTS.

Comparison of cottonseed hulls and shredded corn stover 5
  Composition of feeds 6
  Milk and butterfat yield 6
  Object of experiment 5
  Plan of experiment 5
  Roughage refused 8
  Weight of cows 6
Conclusions from all experiments 4
Corn meal vs. corn meal and dried brewers' grains 10
  Milk and butterfat yield 11
  Object of experiment 10
  Plan of experiment 10
  Weight of cows 11
Corn stover, discussion of 8
Cottonseed hulls, discussion of 9
Rolled oats for calf feeding 12
  Method of feeding 13
  Plan of experiment 14
  Weight of calves 15

CONCLUSIONS.

The cottonseed hulls and shredded corn stover fed in this experiment were of equal value as milk and butterfat producers. It should be stated, however, that the hulls were of good average quality, while the stover was below average, especially in palatability.

It is a wasteful practice for farmers to purchase cottonseed hulls at $8.00 per ton when shredded corn stover of inferior quality can be fed with equally satisfactory results.

Rolled oats constitute an excellent substitute for milk in calf feeding. They are highly relished by young calves and materially reduce the cost of feeding where no skimmed milk, or an insufficient amount, is available for the purpose.

The results indicate that 4.4 cents worth of rolled oats (the cost of one pound) when fed in moderate quantity, is nearly equal to one gallon of whole milk.

With corn stover as the exclusive roughage, corn meal and dried brewers' grains have practically equal feeding value when supplemented by a grain ration consisting of one-half cottonseed meal and one-quarter corn meal.

With most cows, the continuous feeding of corn stover as the exclusive roughage results in too rapid shrinkage in milk flow for best returns.

The results of these experiments incline us to recommend to dairymen who are feeding much corn stover, a grain ration consisting approximately of one-half cottonseed meal, one-quarter corn meal, and one-quarter dried brewers' grains, or wheat bran or some other similar light, fluffy, concentrate, depending upon the relative market price of these feeds.

COMPARISON OF COTTONSEED HULLS AND SHREDDED CORN STOVER FOR MILK PRODUCTION.

By JOHN MICHELS, Dairy Husbandman.

Statistics recently gathered by the writer show that a large number of dairymen in North Carolina feed cotton-seed hulls, either alone or in combination with other coarse feeds, as roughage for dairy cows. Indeed it was found that hulls were fed more largely than any other kind of roughage. More than one and one-half times as much hulls as corn stover are being fed.

Why farmers will continue to pay high prices for hulls rather than feed stover can be explained only on the supposition that they do not fully realize the feeding value of stover. This belief is strengthened by the fact that many of them do not even attempt to harvest corn stalks, but allow them to go to waste in their fields.

OBJECT AND PLAN OF EXPERIMENT.

In view of the facts presented above, it was thought desirable to demonstrate the feeding value of corn stover by feeding it in comparison with cotton-seed hulls, one of the most commonly fed roughages.

For this experiment seven grade cows, from two to three months in lactation, were fed during three periods. The roughage consisted of shredded corn stover in the first and third periods, and of cotton-seed hulls in the second period. Closing the test with the same roughage used at the beginning tends to balance up any changes in milk and butter-fat yield due to advanced stage of lactation and the unfavorable effects of continued feeding on dry roughage. The grain ration was the same throughout the test. It consisted of a mixture of 4 pounds of cotton-seed meal, 2 pounds of dried brewers' grains, and 1 pound of linseed meal. All cows received 8 pounds of the grain mixture per day except Nos. 6 and 7, which received 10 pounds. The amount of roughage which the cows received was the same throughout the test, being 14 pounds per individual, with the exception of cows Nos. 1 and 4, each of which received 16 pounds per day.

Each period lasted twenty-two days exclusive of thirteen days preliminary feeding for Periods II and III and twenty days preliminary feeding for Period I. The longer preliminary feeding for Period I was thought desirable because the cows did not take very kindly to an all-dry feed after having been on a ration of equal parts of stover and silage for more than two months prior to the experiment.

The milk from each cow was weighed daily, and weekly determinations were made on composite samples of the milk by the Babcock test. All cows were weighed once a week.

The hulls were mixed with the concentrates before feeding. The stover, on the other hand, was always fed after the concentrates.

The corn from which the stover was made was thoroughly matured before cutting and allowed to stand in small shocks in the field from six to eight weeks, during which time it had received several drenching rains. There was practically no green color left in the stover at the time of shredding; neither were there any corn grains or nubbins found in it. On the whole, the stover was of a rather inferior quality. The following analyses, supplied by the Chemical Division, gives an idea of the grade of the different feeds used in this and the following experiments:

TABLE I.—PERCENTAGE COMPOSITION OF FEEDS.

Feed.	Moisture.	Protein.	Fat.	Nitrogen—Free Extract.	Crude Fiber.	Ash.
Cottonseed Hulls	10.76	5.72	1.04	29.07	51.17	2.24
Cottonseed Meal	6.87	38.93	10.53	28.08	8.79	6.80
Linseed Meal	8.03	34.87	8.81	34.18	8.83	5.28
Dried Brewers Grain	7.92	22.56	5.76	42.14	18.33	3.29
Corn Stover	7.83	4 04	1.31	47.29	35.18	4.35

MILK AND BUTTERFAT PRODUCTION.

The milk and butterfat yielded by each cow during the test are shown in the following table:

TABLE II.—SHOWING MILK AND BUTTERFAT YIELDS, AND LIVE WEIGHT.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds
1	I. Stover	335.2	5.0	16.76	660
	II. Hulls	332.8	5.4	17.97	656
	III. Stover	316.7	5.4	17.10	639
2	I. Stover	400.2	4.1	16.40	687
	II. Hulls	342.	4.2	14.36	687
	III. Stover	316.6	4.2	13.30	672
3	I. Stover	405.4	4.4	17.83	587
	II. Hulls	353.4	4.9	17.81	571
	III. Stover	340.3	4.8	16.33	569

TABLE II.—Continued.

No. Cows.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds.
4	I. Stover	484.4	4.5	19.55	824
	II. Hulls	375.	4.7	17.62	794
	III. Stover	331.	4.6	15.23	767
5	I. Stover	468.7	4.5	21.19	805
	II. Hulls	409.8	4.5	18.44	785
	III. Stover	363.4	4.5	15.85	806
6	I. Stover	359.7	4.4	15.82	784
	II. Hulls	278.5	4.8	13.36	769
	III. Stover	262.4	4.7	12.33	778
7	I. Stover	335.6	5.2	17.45	688
	II. Hulls	322.9	5.4	17.43	657
	III. Stover	284.3	5.7	16.77	658

From the results contained in Table II it will be seen that all cows fell off in milk yield during the Hull period and again during the Stover period following, the amount varying with different individuals. It is noteworthy also that in the case of cows Nos. 3, 4 and 6 the percentage of fat present in the milk was a trifle higher in the Hull period than in the Stover period. This may possibly be due to the rather large shrinkage in milk in these instances.

The total yield of milk and butter-fat for each period is shown in the table below:

TABLE III.—Showing Total Yield of Milk and Butterfat and Total Live Weight.

Periods.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I. Stover	2789.2	125.0	5060
II. Hulls	2414.4	116.5	4919
III. Stover	2224.7	107.4	4889

Averaging the results of the two stover periods in Table III we find that the cows yielded 2482.0 pounds of milk during the Stover period against 2414.4 pounds for the Hull period. Similarly the cows during the Stover period yielded 116.2 pounds of butter-fat as against 116.5 pounds for the average of the Hull periods, showing in this experiment that cotton-seed hulls and corn stover had practically equal value as milk and butter-fat producers.

Table II shows that the average weight of the individual cows was less during the Hull period than during the first Stover period, excepting cow No. 2, whose weight remained the same. Going from the Hull period to the last Stover period we find that four of the cows lost in weight, two gained and one remained practically unchanged.

Taking the weights of the cows collectively, we find that they averaged 111 pounds less in the Hull period than in the first Stover period, and 30 pounds less in the last Stover period than in the Hull period.

On the whole it may be concluded that the cotton-seed hulls and corn stover used in the experiment had about equal value in maintaining the live weight of the cows.

HULLS AND STOVER REFUSED.

The roughage refused at each feed was weighed and recorded separately for each cow. It was found that the amount of stover refused averaged from 3 to 4 pounds per cow, with the exception of cow No. 3 (the lightest in weight), which refused from 4 1-2 to 5 pounds daily.

At the beginning of the Hull period an attempt was made to feed the hulls and concentrates separately. This proved a failure, since most of the cows refused the hulls, and only a few ate as much as one-half the allowance supplied them. After the second day, therefore, the hulls were always mixed with the concentrates before feeding. Even when fed in this manner some of the cows showed a strong dislike for the hulls the first week, after which practically the entire amount supplied was consumed except in the case of cows Nos. 6 and 7, each of which would occasionally refuse from 1 to 3 pounds per day.

CORN STOVER.

For years corn stover has formed an important part of the roughage fed to cattle in the live stock sections of this country. This feed is especially suited for feeding in cotton growing sections where the majority of farmers have insufficient stock to warrant the erection of silos; and even where farmers have silos there will always be more or less stover to feed because of the large amount of corn which is planted solely for the grain it yields, leaving the stover as a by-product. But because it is a by-product it is not necessarily to be inferred that it is worthless; yet so it is undoubtedly considered by many, as evidenced from the thousands of acres of cornstalks which are allowed to go to waste in the fields every fall.

An important consideration in making stover is to have it palatable. The corn should therefore be cut as soon as sufficiently matured, and be placed in shocks containing from one hundred to two hundred stalks. During fair weather the corn may be husked, as a rule, from two to three weeks after it is cut. When husked by a machine the stover is shredded at the same time, and placed under shelter. When husked by hand the stover should be sheltered with the same care and promptness. Long exposure of the stover in the fields greatly diminishes its nutritive qualities as well as its palatability. The damage to stover is especially great when drenched by heavy rains.

It is usually best to cut the stover in small pieces, say from one to three inches long, before feeding. Less is wasted by cattle in this way than when fed uncut or unshredded. There are thousands of stockmen, however, who are at present feeding uncut stover, and our own experience along this line convinces us that dairymen would save considerable money by feeding even the uncut stover, rather than purchasing cotton-seed hulls.

While much has been said in favor of feeding corn stover, it should be distinctly understood that the greatest feeding value of the corn plant is obtained when placed in the silo.

COTTONSEED HULLS.

Aside from their low nutritive value cotton-seed hulls do not seem very well suited for dairy cows, on account of their low palatability and digestibility. With the cows used in these experiments it was found that a majority refused the hulls when they were offered them unmixed with concentrated feeds. When mixed with the concentrates the cows would eat them, largely because they were obliged to do so in order to get the concentrates. On general principles it can not be considered good feeding to thus force cows to swallow a lot of unpalatable material, especially when such material has such a low digestibility. Digestion experiments show that only 41 per cent of the total dry matter in hulls is digestible as against 60 per cent for corn stover. Our experiments were of too short duration to show any appreciable digestive disturbances from the feeding of such undigestible material as cotton-seed hulls, but it can not be denied that continuous feeding of any undigestible feed must ultimately prove deleterious to the usefulness of a dairy cow.

CORN MEAL VERSUS A MIXTURE OF CORN MEAL AND DRIED BREWERS' GRAINS AS A SUPPLEMENT TO COTTONSEED MEAL FOR MILK PRODUCTION.

OBJECT OF EXPERIMENT.

A problem that confronts many farmers is to find a cheap and satisfactory grain supplement to cotton-seed meal for dairy cows. Owing to its high protein content, cotton-seed meal can not be satisfactorily used as the sole concentrate, except possibly where silage, made from well-eared corn, constitutes the roughage.

Hitherto wheat bran has been commonly fed in connection with cotton-seed meal and when the latter is not too high priced, this combination gives very satisfactory returns. But during the past year the price of wheat bran has been so high as to make its use as a cow feed almost prohibitive.

A careful study of prices of different feeds suggested the use of either corn meal or dried brewers' grains, or both, as a satisfactory supplement to cottonseed meal. Both of these feeds could be bought at a lower price than wheat bran, and both were believed to have a higher feeding value.

The dried brewers' grains are of a light, fluffy nature and are highly relished by cattle; yet, owing to their high protein content, the objection may be raised that they do not form a balanced ration with cottonseed meal.

From the standpoint of balancing the nutrients in a ration where much cottonseed meal is fed there appears to be no feed more ideal than corn meal. But owing to the heavy nature of both the corn and cottonseed meal a combination of the two would ordinarily be considered liable to give rise to digestive disturbances.

The above possible objection to corn meal and dried brewers' grains suggested that a combination of the two would probably give the most satisfactory results when used to supplement cottonseed meal, and that possibly corn meal alone could be advantageously used for this purpose if no digestive troubles should arise on account of the heavy character of this feed. Accordingly it was decided to test these points by feeding a mixture of corn meal, dried brewers' grains and cottonseed meal in comparison with a mixture of corn meal and cottonseed meal.

PLAN OF EXPERIMENT.

Six grade cows, from three to four weeks in lactation, were used for the experiment. The feeding was divided into three periods. During the first period the cows received cottonseed meal and corn meal in equal proportions. In the second period the cows received a mixture of 4 parts cottonseed meal, 2 parts corn meal and 2 parts dried brewers' grains. The feed in the third period was the same as that of the first. The daily allowance of grain per cow during the entire test amounted to 10 pounds for cows Nos. 4 and 5, and 9 pounds for cows Nos. 2, 3 and 6. The roughage supplied throughout the test consisted of 14 pounds of shredded corn stover per cow daily. The stover was the same as that used in the Stover and Hull Experiment.

Each period lasted twenty-one days, and only Period I was preceded by seven days preliminary feeding. Closing the experiment with the same ration used at the beginning tended to balance up any changes in milk and butter-fat yield which might be attributable to the advancing stage of lactation, to loss of continuous feeding of unpalatable roughage, to change in weather and other environmental factors.

The grain was always fed before the roughage. The milk from each cow was weighed daily, and weekly samples of the milk were tested by the Babcock test. All cows were weighed regularly once a week.

The results obtained with the individual cows during the different periods of the test are presented in the following tables:

TABLE V.—Showing Milk and Butterfat Yields and Live Weight.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight Cows—Pounds.
1	I	528.1	4.36	23.03	721
	II	511.6	4.20	21.49	717
	III	493.4	4.10	20.23	719
2	I	527.1	4.13	21.77	608
	II	459.0	4.30	19.74	606
	III	412.0	4.16	17.14	612
3	I	455.5	4.36	19.86	787
	II	410.8	4.43	18.80	767
	III	390.9	4.26	16.65	784
4	I	542.7	4.40	23.85	724
	II	486.4	4.45	21.64	738
	III	461.3	4.30	19.84	740
5	I	612.8	4.00	24.51	795
	II	528.8	3.90	20.62	786
	III	494.0	3.93	19.41	796
6	I	520.2	.83	19.92	876
	II	462.9	3.80	17.59	854
	III	428.2	3.73	15.97	847

Summarizing the results contained in Table V we find the following:

TABLE VI.—SHOWING TOTAL YIELD OF MILK AND BUTTERFAT AND TOTAL LIVE WEIGHT.

Period.	Ration.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I	Corn + Cottonseed Meal	3186.4	132.97	4506
II	Corn + Dried Brewers' Grains + Cottonseed Meal	2859.5	119.38	4468
III	Corn + Cottonseed Meal	2679.8	109.24	4498
Average of Periods I and III		2933.1	121.10	4502

An inspection of the results in the two preceding tables shows there was a gradual falling off in the milk and butter-fat yield of the cows, individually as well as collectively, from the beginning to the end of the test. The decrease was so uniform that it could not, therefore, be attributed to a change in the grain ration, but must be laid to the unpalatable roughage fed. Table VI shows that the average milk and butter-fat yield of Periods I and III, in which corn meal and cotton-seed meal were fed, was slightly larger than that of Period II, in which dried brewers' grains replaced pound for pound one-half of the corn meal fed in Periods I and III.

Although no digestive disturbances resulted from the feeding of the combination of corn meal and cottonseed meal, yet the trial was too short to warrant a statement as to what the effects of such a mixure of heavy feeds might be, if fed continuously for a longer time.

Pending further investigation along this line, therefore, we are inclined to recommend to dairymen who are feeding much stover a grain ration consisting approximately of one-half cottonseed meal, one-quarter corn meal and one-quarter dried brewers' grains, or wheat bran, or some similar light, fluffy concentrate, depending upon the market prices of these feeds.

ROLLED OATS AS A SUBSTITUTE FOR MILK IN CALF FEEDING.

One of the essentials in building up a productive dairy herd is to raise the heifer calves from the best milkers. This is also the surest way to keep a herd free from disease. Moreover, where skimmed milk is available for feeding, the practice of raising the best calves is also the cheapest means of increasing and improving the dairy herd.

Hundreds of dairymen, however, who are supplying milk to towns and cities either have no skimmed milk at all or an insufficient quantity for calf rearing. Hence they prefer killing the calves to feeding them high-priced milk. In order to induce this class of dairymen to raise their calves, it became clear to us that some cheap and satisfactory substitute had to be found that would take the place of high-priced milk for feeding.

Grade Calf Reared on Rolled Oats.

In our efforts to find such a substitute, we were guided by the following requirements: that a feed that could take the place of milk for young calves must be very palatable and digestible, rich in muscle and bone-forming materials, and practically free from crude fibre. Cooked rolled oats suggested themselves as meeting all these requirements with the exception, perhaps, that there might be a possible deficiency in ash or bone-forming material. This feed was therefore given a careful test.

It was estimated in the beginning, from the composition of the feeds, that one pound of rolled oats was approximately equal in feeding value to one gallon of whole milk, and our feeding trials were conducted upon this basis. The rolled oats were prepared by adding boiling water to them at the rate of one gallon of water to twelve ounces of rolled oats, and the mixture was then allowed to stand until cool enough to feed.

The feeding of a number of calves was simplified by preparing the rolled oats for all in a can of suitable size, from which the proportionate amount for each calf was measured out with a dipper.

All the calves used in the experiment, with one exception, were grade Jerseys, light to medium in weight. The daily allowance per calf during the thirteen weeks of the experiment was as follows:

First week—10 pounds whole milk.

Second week—8 pounds whole milk, 4 ounces rolled oats.

Third week—6 pounds whole milk, 8 ounces rolled oats.

Fourth week—4 pounds whole milk, 12 ounces rolled oats.

Fifth week—2 pounds whole milk, 12 ounces rolled oats, 0.2 pound grain mixture.

Sixth week—2 pounds whole milk, 12 ounces rolled oats, 0.4 pound grain mixture.

Seventh week—2 pounds whole milk, 12 ounces rolled oats, 0.6 pound grain mixture.

Eighth week—2 pounds whole milk, 12 ounces rolled oats, 0.8 pound grain mixture.

Ninth week—2 pounds whole milk, 12 ounces rolled oats, 1.0 pound grain mixture.

Tenth week—12 ounces rolled oats, 1.0 pound grain mixture.

Eleventh week—12 ounces rolled oats, 1.0 pound grain mixture.

Twelfth week—12 ounces rolled oats, 1.2 pounds grain mixture.

Thirteenth week—12 ounces rolled oats, 1.2 pounds grain mixture.

The grain mixture consisted of one part each of corn meal, linseed meal and wheat bran.

The milk was always added to the oat preparation just previous to feeding.

In addition to the above feeds, the calves received all the hay they would eat during the winter, while in spring they received one feed of hay with pasturage additional.

On the basis that one pound of rolled oats is equal to one gallon of whole milk, and that whole milk is worth 8 cents per quart to milkmen, the cost of the milk for a thirteen-weeks-old calf receiving no rolled oats is $26.96. When rolled oats (which cost 4.4 cents per pound delivered in barrel lots) are substituted for milk as shown above, the cost of the calf feed for the same period is only $12.46, a saving of $14.50 in favor of the rolled oats.

The weekly weights of the calves fed rolled oats and those of two calves fed skimmed milk as a check on the work are presented in the following table:

TABLE VII.—Showing Weekly Gains of Calves Fed Rolled Oats and Skimmed Milk.

Age of Calf.	Weekly Weight of Calves—Pounds.										
	Rolled Oats.									Skimmed Milk.	
	Calf No. 1.	Calf No. 2.	Calf No. 3	Calf No. 4.	Calf No. 5.	Calf No. 6.	Calf No. 7	Calf No. 8.	Calf No. 9.	Calf No. 10	Calf No. 11
At birth	68	88	62	60	62	60	66	50	49	60	46
One week	69	94	70	65	70	------	------	------	------	68	52
Two weeks	78	101	77	70	78	------	------	------	------	74	62
Three weeks	84	106	85	74	74	------	------	------	67	82	67
Four weeks	88	115	88	81	81	------	------	------	------	87	74
Five weeks	94	128	93	86	86	100	------	76	------	97	82
Six weeks	99	131	102	88	90	104	------	------	------	106	90
Seven weeks	108	140	111	91	98	108	------	------	------	115	96
Eight weeks	118	147	120	101	107	114	------	------	------	122	100
Nine weeks	125	159	129	112	115	123	------	------	------	135	118
Ten weeks	139	167	140	122	124	129	------	------	------	146	125
Eleven weeks	151	171	151	134	137	139	144	------	------	159	130
Twelve weeks	170	178	159	141	145	153	154	------	------	170	137
Thirteen weeks	180	188	169	155	155	166	163	168	159	180	146
Average daily gain	1.28	1.16	1.18	1.00	1.00	1.16	1.09	1.30	1.12	1.32	1.10

Skimmed-milk calf No. 10 received the following daily ration:
First week—10 pounds whole milk.
Second week 7 pounds whole milk and 4 pounds skimmed milk.
Third week—4 pounds whole milk and 8 pounds skimmed milk.
Fourth week—2 pounds whole milk, 10 pounds skimmed milk.
Fifth to fourteenth week—14 pounds skimmed milk.

Calf No. 11 received only 8 pounds of whole milk the first week, and subsequently was fed the same allowance of whole milk as calf No. 10, but received 2 pounds less of skimmed milk per day. The grain and roughage for the two skimmed-milk calves were the same as those for calves fed on rolled oats.

Table VII shows that the calves fed on rolled oats made practically the same gains as those fed skimmed milk.

Considering that all calves but No. 2, which was a grade Holstein, were light-weight, common-grade Jersey calves, and that the allowance of whole milk and the rolled oats equivalent were less than is usually fed, the gains here reported are considered as fairly satisfactory. The calves showed good bone and muscle development.

We strongly recommend the feeding of cooked rolled oats to calves for all who either have no skimmed milk or an insufficient quantity for calf-rearing; and we confidently expect that a trial by such dairymen will result in the rearing of every calf that promises to become a valuable animal in the dairy.

One thing that especially commended itself in the rolled oats feeding was the evident relish with which the calves devoured them. The extra labor entailed in the feeding of the rolled oats was insignificant as compared with the saving effected.

One precaution to observe in feeding rolled oats to calves is not to use it in too large quantities, owing to the laxative character of this feed. Indeed, our experience indicates that it is best not to feed more than 12 ounces daily to each calf. It is important also that the rolled oats and milk be supplied as near the temperature of blood heat as possible.

In these trials the grain was always supplied first and the roughage later, the milk and oats being fed immediately after the grain. The latter was fed from a sterile tin bucket, which was also used for feeding the milk and rolled-oat mixture.

The calves were removed from the cows when twenty-four hours old, and received regularly two feeds daily, except during the first few days, when they were fed three times per day.

THIRTY-SECOND ANNUAL REPORT

OF THE

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDING JUNE 30, 1909

INCLUDING SCIENTIFIC PAPERS AND BULLETINS,
Nos. 200, 201, 202, 203, 204

WEST RALEIGH, N. C.

RALEIGH
E. M. UZZELL & CO., STATE PRINTERS AND BINDERS
1911

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	LOCKE CRAIG	Asheville

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

FEB 13 '40

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR.
WEST RALEIGH, N. C., June 30, 1909.

To His Excellency, WILLIAM W. KITCHIN,
Governor of North Carolina.

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1909.

Trusting that this report will prove satisfactory to your Excellency, I am,
Yours very truly,
C. B. WILLIAMS,
Director.

TABLE OF CONTENTS.

PAGE.
Board of Trustees and Experiment Station Staff........................ 2
Letter of Transmittal.. 3
Report of Director and Agronomist.............................. 7
  Report of Chemist 17
  Report of Biologist 20
  Report of Poultryman 23
  Report of Horticulturist 26
  Report of Animal Husbandman............................... 28
  Report of Dairy Husbandman................................ 31
  Report of Entomologist 32
  Report of Veterinarian 34
Financial Statement... 36
Scientific Papers:
  Effects of Different Fertilizing Materials Upon the Maturity of Cotton. 37
  Some Facts Concerning Those Characters of the Corn Plant Associated with Yield and Factors Which Influence Them............... 41
  Variation of Fungi Due to Environment.......................... 47
  Carnation Alternariose.. 72
  Hypochnose of Pomaceous Fruits................................ 76
  A New Fig Anthracnose (Colletotrichose)........................ 86
  Harlequin Cabbage Bug *(Murgantia histrionica)*.................. 90
  Is *Neocosmospora Vasinfecta* (Atk.) Smith, the Perithecial Stage of the Fusarium Which Causes Cowpea Wilt?........................ 100
  The Scuppernong As a Profitable Crop—Methods of Growing, Keeping, and Wine-making Used At Its Place of Origin.................... 117
  II—Studies in Soil Bacteriology—Ammonification in Soils and in Solutions 119
  III—Studies in Soil Bacteriology—Concerning Methods for Determination of Nitrifying and Ammonifying Powers of Soils.............. 129
Press Bulletins:
  No. 16—Selecting Seed Corn for Larger Yields..................... 145
  No. 18—Apple Bitter Rot.. 147
  No. 19—Suppression of Terrapin Bugs.............................. 148
  No. 20—Spring Destruction of Terrapin Bugs....................... 150

APPENDIX.

BULLETINS:

No. 200—Feeding Fermented Cotton-seed Meal to Hogs.

No. 201—Scuppernong and Other Muscadine Grapes—Origin and Importance.

No. 202—Manufacture and Marketing of Cottage Cheese, Skimmilk-Buttermilk and Ice-cream.

No. 203—Corn Weevils and Other Grain Insects.

No. 204—Some Factors Involved in Successful Corn Growing.

THIRTY-SECOND ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR ENDING JUNE 30, 1909.

BY THE DIRECTOR.

Generally, the work of the Station in all its branches has been increased and actively carried forward by the various workers in a fairly satisfactory manner. Below is given, briefly, something as to the nature and scope of the work which is being conducted by the several Divisions of the Station. This summary is made up from the reports of the different workers and from the observations of the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has progressed actively along the same general lines as previously reported. Considerable effort has been exerted in the determination of best fertilizer combinations and the most economical quantities of fertilizers to use per acre, especially for cotton and corn. These experiments have shown unmistakably that phosphoric acid is the chief deficiency of our soils here and that potash is the one less needed for maximum yields. The field results have been confirmed by chemical analyses of the soil. The fertilizer formulas used largely by the farmers in the Piedmont section of the State for cotton are not the ones which, judging from our results, afford the greatest profit per acre. The phosphoric acid in them should, as a general thing, be increased, while the potash might be decreased.

The variety tests this year embrace a study of 68 varieties of corn; 42 of cotton; 23 of soy, adsuki and seta beans; 30 of cowpeas; 15 of wheat; 49 of oats, and 4 of clover. In addition to this comparison of varieties with reference to yield, an intimate study is, at the same time, being made of the characters of each variety, with the hope of determining those which are correlated in the different varieties with high yield and superior worth. Variety-distance tests with 68 varieties of corn and 3 of cotton, each of widely different characters, are being conducted to ascertain what distancing of the different varieties produces the best results. From the field seed-selection experiments with corn, cotton, wheat and oats, recently started, much is expected in the way of improvement and practical scientific information. In the variety test of oats an effort is being made to determine those varieties which are best adapted for fall and spring sowing. Marked differences have developed, not only in yield, but also in earliness and consequent adaptation for different soils and localities and for specific purposes. For sowing in combination with crimson clover or Canada field peas, the earliness in maturity of Burt, Kherson and Culberson varieties especially fits them for this purpose, as they reach the haying stage at practically the same period as do the clover and peas. The white-blooming crimson clover may be used in mixtures with later maturing varieties, such as Red Rustproof or Appler, as it blooms ten to fourteen days later than the regular crimson clover.

Investigations are being carried on with 68 varieties of corn to determine the factors which operate in the production of suckers on the corn plant and to ascertain the relation which their undisturbed development bears to yield of grain and stover. As these investigations advance, many interesting and economic features present themselves which will shed much light upon the nature of the characters of corn varieties when grown under widely varying conditions of fertilization, distancing and season.

Top-dressing experiments with nitrate of soda and sulphate of ammonia on oats and wheat are being conducted to determine their actual and relative values for this purpose. A comparative study is also being made of different carriers of phosphoric acid and nitrogen for fertilization of cotton and corn.

Many combinations of legumes are being grown to ascertain their relative value for hay and pasturage.

A systematic effort is being made to determine the effects upon percentage of lint to seed, and length and tensile strength of the staple of cotton by allowing the seed cotton to stand exposed for a year to the average conditions prevailing on the farm. This Division is especially fortunate in having under its control considerable land which may be used in making direct application, on a considerable scale, of the facts which are evolved from the carefully planned experiments which are being conducted along different lines. By this means it is felt that a broader conception of agronomical problems in general and their practical solution is obtained.

DIVISION OF CHEMISTRY.

During the year the Chemical Division has sustained intimate cooperative relations with the Biological Division in soil nitrification and ammonification studies and with the Animal Husbandry and Veterinary Divisions in cotton-seed meal toxicity investigations. The preparation of the twenty-two fractions used in the cotton-seed meal feeding experiments with hogs and guinea pigs has largely been performed by the workers of this Division. Much work has been done in connection with these investigations in making chemical determinations of the composition of various feeds, fractions of cotton-seed meal employed in the experiments and of the urine secreted by animals fed on each of these. The Division has been materially strengthened by the addition of an assistant, and, during the first ten months of the year, 3,825 determinations on 1,414 samples have been made. In the bacteriological soil survey of the State which is being carried on this summer co-operatively by this and the Biological Division, the examinations of the Bacteriologist for nitrifying and ammonifying efficiency, nitrifying and ammonifying inoculating power, nitrifying capacity, and bacterial count are being supplemented in each case by a careful chemical determination of the amount of nitrates, nitrites, and ammonia present.

DIVISION OF BIOLOGY.

During the year the research work has been carried forward largely along lines previously begun and reported on. In co-operation with the National Bureau of Plant Industry, this Division in continuation of its Plant Disease Survey of the State has conducted much correspondence with farmers and public-school teachers in order to determine definitely how widespread certain plant diseases are in different localities and to ascertain the amount of damage to crops and fruits they produce. New diseases of the apple, lettuce, clover, tuberose, fig, carnation, privet, peanut and vetch occurring in the State have been studied and the fungus causing each has been isolated, identified, and described.

The experiments which are being conducted at Auburn on soil badly infected with watermelon wilt will be continued in an effort to secure strains of melons which possess desirable eating and shipping qualities and which may be successfully grown upon soils affected with this disease. The importance of this work cannot be too strongly emphasized, as the melon industry is an important one and in many localities is beginning to be menaced by the appearance and rapid spread of this disease. Melons cannot, to a profitable extent, be grown at present on a badly infected field, and unless wilt-resistant varieties or strains are bred or found, the industry will be wiped out in certain important infected areas of rapidly increasing size.

The tobacco-wilt experiments are this year continued at Creedmoor, which is located in the light tobacco belt of Granville County. Eleven strains of tobacco are being used in the work, and they were put out on badly infected soil. Although there did not develop any marked difference between the ability of the Sumatra, Turkish and Italian types to withstand the wilt, yet the finer qualities of the Sumatras has led to the crossing and use of two strains of this type with the native bright tobacco of the infected section with the hope of securing wilt-resistant strains of as nearly the same quality as possible as the native bright tobacco. It is planned to devote during the present season about one-fourth of the space allotted to this experiment to a field-study of the resistance and quality of these crosses made last year.

In the lettuce-drop investigations efforts have been directed principally along the line of preventing the formation of sclerotia by the fungus causing this trouble, as it seems to be the only means this disease has of being carried over winter. Should any of the methods devised prove effective against the formation of sclerotia, then the eradication of the disease from infected lettuce-beds seems assured.

The soil bacteriology investigations which this Division is carrying on in co-operation with the Chemical Division have been greatly strengthened by further work and extension. Results secured have brought out rather conclusively the importance of conducting tests to determine the ammonifying and nitrifying powers of soils on the soils themselves, rather than by the use of culture solutions in the usual way, as there seems to be no definite relation whatever between the results on nitrification and ammonification secured on the soil itself and the solution. Methods have been devised for determining fairly accurately the nitrifying and ammonifying power of soils, using the soil as a medium. In marked contrast to the commonly accepted notion that all soils are well supplied with nitrifying organisms, it has been found that 71 per cent of the local soils which have undergone examination have shown very low nitrifying power. The facts have led to the inauguration of a new line of experiments which are designed to study the relative acceptability to plants of nitrate-nitrogen and ammoniacal nitrogen. The experiments are being conducted under complete bacteriological and chemical control. To supplement these, a systematic bacteriological survey of the different soil types of the State has been started, and on each soil determinations of its nitrifying and ammonifying power will be made. Contrary to the accepted idea, results thus far secured seem to indicate very strongly that the presence of organic matter in the soil does not always exert an inhibiting influence upon the activity of nitrifying organisms.

The ptomaine studies which were started last year have been temporarily suspended, due to the absence of suitable material and because of pressure of other investigational work.

DIVISION OF POULTRY.

The operations of the Poultry Division have been to a large extent carried on in the direction of testing various systems of feeding young chicks, managing incubators and brooders and comparing different feeds and combinations for the production of eggs and meat. From the results secured in the cotton-seed meal feeding experiments it was demonstrated that this material may be fed without detriment to the health of the poultry to the extent of one-fourth of a ration consisting of cotton-seed meal and corn, when the stock is allowed range on grass or other green crops. It will be noticed from results of subsequent experiments that, although the ration containing cotton-seed meal costs less than the ones containing meat and bone meal, yet the latter ones, by inducing earlier development and laying, have produced the cheapest gains in weight and egg production. During the summer it is planned to study the value of skim-milk as a substitute for meat meal and cotton-seed meal.

In the pedigreed breeding experiments for egg production, work has been continued along the same general lines as previously reported. Some of the Barred Plymouth Rock hens used in this work have made a good showing, as also have their pullets. Last year Barred Plymouth pullet No. 7113 laid 143 eggs in seven months. Several daughters of this hen are being used this year in furtherance of the work and studies. The inbreeding work started last year is being continued, but results will not be expected before next season.

In the incubator experiments an effort is being made to determine if it is advisable to artificially supply moisture to and use disinfectants in the incubators before each hatch comes off. In these comparative studies, eggs from the same hens are being used in order to eliminate as far as possible the effects of differences in individuality. Experiments with the fireless brooder have demonstrated that they may be operated successfully, but that the chief drawback to their use is the greater amount of attention which the chicks confined in them require for the first few days.

DIVISION OF HORTICULTURE.

The attention of the Horticulturist has been confined chiefly to preparation for and in a study of "double flower" and self-sterility of blackberries and dewberries with the purpose of determining the nature and cause of these abnormalities. The work was started last year and is now fairly well under way. As 23 varieties of blackberries and 14 varieties of dewberries are embraced in these investigations, it is planned also to make careful observations as to the relative standing of these in reference to earliness and amount and character of fruit. A study will be made at the same time of the influence of many fertilizer carriers and combinations upon yield, "double flower" and self-sterility of the various varieties under experimentation. The careful microscopic study of the doubled flowers and accompanying rosette growth of stems and leaves of the Wilson blackberry and of the character of the flower-parts of the notably self-sterile Premo dewberry, which is being conducted in the laboratory simultaneously with the field work, will doubtless reveal much as to the nature and cause of "double flower" and self-sterility.

Field experiments were begun this spring with eight varieties of dewberries to determine the ability of the several varieties to set fruit without cross-pollination. These were undertaken by enclosing 500 flower clusters in paper bags before the flowers opened. Results thus far secured by the Horticulturist seem to indicate that "double flower" is intimately associated in some way with early dropping of the old leaves during the previous year and to the premature development of buds which would normally produce fruit the succeeding year.

Some preliminary work with figs, Japanese plums, and muscadine grapes has been gotten well under way during the year. A bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes is now in press. This will be followed by study and publication on other features of muscadine grape growing. It is a notable fact that most of the leading varieties of muscadine grapes have been originated in this State.

DIVISION OF ANIMAL HUSBANDRY.

The Animal Husbandman has devoted considerable effort and time in providing new equipment and in getting under way new lines of experimentation. A major portion of his efforts has, however, been given to a careful supervision of the investigations which are being conducted jointly by the Animal Husbandry, Veterinary and Chemical Divisions to determine the cause for the disastrous results which frequently follow the feeding of cotton-seed meal to swine, and to isolate, if possible, the toxic principle, if such it may be. Feeding experiments which have been carried on by other experimenters with cotton-seed meal up to the present have been of an empirical nature, and have afforded information only with reference to the quantity which may be fed, length of the feeding period and the symptoms and post-mortem revelations produced by overfeeding. During the year 28 pigs and 93 guinea pigs have been used in carrying on these investigations. Out of the 23 fractions of cotton-seed meal that have been fed, 7, having proven practically innocuous, have passed from under further experimentation for the present. For comparison with the results secured with feeding cotton-seed meal, linseed meal and blood meal, as highly concentrated proteinaceous feeds, are being fed with the same supplementary feeds and in the same proportions to guinea pigs under control conditions. A series of experiments has recently been started to determine the toxicity of cotton-seed meal when fed in conjunction with corn and green clover leaves to guinea pigs. From the results secured in feeding cotton-seed meal to horses and mules, it is felt that as a supplement to ear corn, shelled corn and corn-and-cob meal, this feed cannot generally be fed in larger quantities than three-quarters to one pound per day and have it eaten clean. When fed in connection with dried brewers' grains or wheat bran one and one-half pounds were readily eaten. During the course of the experiments it has been observed that horses eat the meal more readily than do the mules.

Experiments are being conducted to determine the value of green crops in general as pasturage for hogs and to further ascertain the relative value of oats, rye, and rape, sown alone and in different combinations. In these experiments cowpeas, peanuts, and sweet potatoes have been used, allowing the hogs to run on them *ad libitum* after the crops have reached almost maturity. By a system of rotation it has been possible to have green crops practically the entire year for the hogs to run on. The results thus far secured from this succession of crops have been quite encouraging. Grading experiments have been started and are well under way with hogs. For this work a pure-blooded Berkshire sire is being used.

During the year a Bulletin on Feeding Fermented Cotton-seed Meal to Hogs has been prepared and issued, and two others are in course of preparation.

Plans are being developed for this Division to feed experimentally this fall a carload of high-grade mountain steers.

DIVISION OF DAIRY HUSBANDRY.

The Dairy Husbandman has, during the year, given much time to working out the details of a commercial method of preparing cottage cheese. A feeding experiment with eight dairy cows has been conducted to determine the relative economy of feeding medium and narrow nutritive rations for milk and cream production under North Carolina conditions. The results of this experiment and of cottage cheese work are now in Bulletin form ready for publication. During the year Bulletins on Handling and Marketing of Milk and Cream and Feeding Experiments with Cows and Calves have been prepared and published.

DIVISION OF ENTOMOLOGY.

Much time of this Division has been devoted to studies of the life-history and habits of the cabbage webworm, harlequin cabbage bug and plum curculio, and during the year two Press Bulletins giving directions for combating the harlequin bug have been prepared by the Entomologist and issued.

The fumigation experiments which have been carried on have demonstrated rather strikingly the unreliability of carbon bisulphide as a remedy against corn weevils in the average corn bin, especially when used in the quantities generally recommended per thousand cubic feet. Otherwise following the commonly given directions in using this agent, but employing twenty times the quantity generally recommended, it was found that it was not effective when used even in this quantity in the Station barn as a destroyer of weevils. Sulphur fumes were tried and were found satisfactory so far as killing the weevil was concerned, but cannot be recommended for general use, as the fumes materially reduce the germinating power of corn thus treated. The plum and apple trees at the Poultry farm which became badly infested with San José scale have almost been freed from it by systematic spraying. The apple trees belonging to the Station have also been kept quite free from the ravages of codling moth by two sprayings, just before the trees bloom, with Bordeaux mixture containing three pounds of arsenate of lead to fifty gallons of the mixture.

An insect collection, representing all the beneficial and injurious forms occurring in the State, with records of dates and places of occurrence, is gradually being brought together.

DIVISION OF VETERINARY SCIENCE.

The time of this new Division has largely been taken up in aiding in carrying forward the cotton-seed meal feeding investigations which the Division is conducting jointly with the Animal Husbandry and Chemical Divisions. The Veterinarian has made daily observations and kept records of the weight, temperature, pulsation and respiration of a good many of the hogs and guinea pigs which are being employed to further the investigations. A study in many cases is being made of the blood which is diseased by prolonged cotton-seed meal feeding. All animals dying have been subjected to post-mortem examination and all revelations as to internal derangement were carefully noted. In many instances diseased tissues were preserved for subsequent microscopic examination and study.

In co-operation with the Biological Division, this Division has done some work along the line of inoculating milk with dirt and germs from different sources to determine if such milk after a sufficient lapse of time would produce ptomaine poisoning when injections of it were made into guinea pigs. Some work has been carried on during the year to determine the value of a recently discovered serum as an effective preventive against hog cholera and to determine the relative worth of turpentine and thymol as vermifugal agents for hogs infested with worms.

POLICY OF THE STATION.

It would appear that the Station can best subserve the purposes of its creation by confining its efforts as largely as possible to investigational work along a few lines which have been carefully planned, with a clear conception of the ends to be attained, by strong and specially equipped men of experience who are broad, painstaking, inventive, resourceful and are not afraid to work and who can distinguish between truth and opinion and between fact and theory. To a large extent, agricultural education, which is making such rapid progress in these latter days, is largely limited in its development by the advances made by the Experiment Stations in supplying material of a fundamental nature for teaching purposes. The Station, under the provisions of the Adams Act, has resources for carrying on research work of an original and fundamental nature in agriculture.

An effort is being made to have all work of an investigational nature so planned and conducted that the results secured will not only have scientific worth, but will also have direct economic value. Although it has no direct bearing on investigations under way, some attention has been devoted to an improvement in the appearance of the grounds, buildings and general surroundings, because it is felt that the manner in which the general operations of the Station are conducted will be a potent factor in determining the local standing and influence of the Station, if not more.

NEW BARN AND SILO.

During the year a new up-to-date gambrel-roof barn has been finished. It is 100 feet long and 42 feet wide and has haymow space for holding something like 150 tons of forage. It is ideally located, well lighted and ventilated and is provided with roomy granaries, with stalls and driveways and sliding doors at all openings. At the east end of the building a large end haymow door is arranged with flexible wire cable, pulleys and weights, and is made to slide in guides on the exterior of the building. Hay trackage and carrier run the full length of the barn.

At the west end of the barn a stave silo, of 130-ton capacity, is conveniently located both for filling and feeding from. The design and arrangements of the barn specially fit it for use in feeding beef cattle.

BULLETINS.

Bulletins have been issued during the year as follows:

No. 200—*Feeding Fermented Cotton-seed Meal to Hogs,* by R. S. Curtis.

No. 201—*Origin and Importance of the Scuppernong and Other Muscadine Grapes,* by F. C. Reimer.

No. 202—*Manufacture and Marketing of Cottage Cheese, Skim-milk-Buttermilk and Ice-cream,* by John Michels.

No. 203—*Corn Weevils and Other Grain Insects,* by R. I. Smith.

No. 204—*Some Factors Involved in Successful Corn Growing,* by C. B. Williams.

No. 16 (Press Bulletin)—*Selecting Seed Corn for Larger Yields.* by C. B. Williams.

No. 18 (Press Bulletin)—*The Apple Bitter Rot,* by F. L. Stevens.

No. 19 (Press Bulletin)—*Suppression of Terrapin Bug,* by R. I. Smith.

No. 20 (Press Bulletin)—*Spring Destruction of Terrapin Bugs,* by R. I. Smith.

The reports of the heads of the several Divisions, financial statement, and scientific papers follow.

REPORT OF CHEMIST.

During the year ended June 30, the Chemical Division has been engaged mainly in investigations relating to nitrogen metabolism in soil and the toxicity of cotton-seed meal.

The investigation relating to soil bacteriology has been conducted in co-operation with the Division of Bacteriology. The analytical portion of that work has involved 5,606 determinations in 1,579 samples of soil and 526 solutions, as follows:

Nitrogen as ammonia by magnesium oxide	1,030
Nitrogen as ammonia by sodium hydroxide	240
Nitrogen as nitrates colorimetrically	107
Nitrogen as nitrates Tiemann-Schulze	1,529
Nitrogen as nitrites Griess	1,446
Nitrogen as nitrites and nitrates, Diphenylamine	1,190
Nitrogen total by Kjeldahl	20
Nitrogen total by Kjeldahl and Nessler	44
	5,606

Three articles have been prepared representing the results of this work. The first was published in the report of the Station for 1908-09, and in the *Centralblatt fuer Bakt,* XXIII, 355-373. The second and third articles have been published by the same journal and are submitted for publication with this report. An article on the work was published in *Science,* March 26, 1909, and a report of article three was made to the North Carolina Academy of Science at its May meeting. A fuller account of the work is shown in the report of the Bacteriologist.

The investigation relating to the toxicity of cotton-seed meal has been conducted in co-operation with the Animal Husbandry and Veterinary Divisions. The analytical portion of this work has involved 60 determinations in 19 samples of cotton-seed meal, and 495 determinations in 129 samples of pig and guinea-pig urine, as follows:

Albumin	129
Nitrogen by Kjeldahl	13
Nitrogen by ureometer	95
Specific gravity	129
Sugar	129
	495

Ash	3
Betain	1
Choline	1
Crude fiber	2
Extract by carbon tetrachloride	2
Extract by ether	4
Extracts by six other solvents	8

Moisture	5
Nitrogen	32
Pentosans	1
Raffinose	1
	60

The feeds for the guinea pigs have been prepared mainly by the Chemical Division and the work so far has been planned mainly by the Division. Fractions of the meal obtained by the use of various solvents have been fed to guinea pigs, and several of these feeds have been found to be nontoxic. The toxic portions are still being fractioned and fed.

The miscellaneous work of the Division has consisted of 72 determinations in 41 samples. The samples were as follows:

Boiler scale	1
Feeding stuffs	18
Fertilizing materials	8
Marls	6
Minerals	3
Soils	4
Urine	1
	41

The 72 determinations in the 41 miscellaneous samples were as follows:

Calcium oxide	9
Carbon dioxide	8
Gold	1
Moisture	4
Nitrogen as ammonia by magnesium oxide	1
Nitrogen as nitrites	1
Nitrogen as nitrates	1
Nitrogen total	13
Phosphorus pentoxide	9
Potassium oxide	4
Sulphur dioxide	13
Acidity	3
Ether extract	4
Humus	1
	72

The grand total of work for the year was 6,233 determinations in 2,294 samples.

During the past year the chief of the Division was elected vice president of the Association of Official Agricultural Chemists, and, in addition to the publications referred to, has published an article in the *Student Farmer, The Progressive Farmer,* and the *News and Observer* upon the importance of the substitution of horse power for human power in agriculture in North Carolina.

Dr. W. A. Syme was appointed State Oil Chemist, and has tendered his resignation, to take effect May 1. I am glad to bear witness to his ability, skill, high character and pleasant personality.

J. K. Plummer was added to the staff of the Division on August 15, and has proven a very rapid and satisfactory worker. He will leave his work here on September 1 to accept a scholarship and pursue post-graduate work at Cornell University. F. W. Sherwood was added to the staff of the Division on May 1, and Hubert Hill has assisted with the work from time to time.

The Division needs more commodious quarters, which I trust will be provided in the new building.

I wish to express my appreciation of the faithful work by the assistants in the Division and to thank you for your cordial co-operation and interest.

Very respectfully,

W. A. WITHERS,
Chemist.

REPORT OF BIOLOGIST.

I hereby submit a report of the Division under my charge for the fiscal year now closing.

The following completed articles represent experiments completed and conclusions reached by work of this Division:

Concerning Apple Diseases.
Hypochnose of Pomaceous Fruits.

Soil Bacteriology (in Co-operation with the Division of Chemistry).
II. Studies in Soil Bacteriology.
Ammonification in Soils and in Solutions.
Concerning the Existence of Non-nitrifying Soils.

Miscellaneous Plant Diseases.
A New Fig Anthrachnose, Colletotrichose.
Alternariose of the Carnation.
Variation of Fungi Due to Environment.

An examination was made of three samples of corn meal received from Wilmington, N. C., which were suspected of bearing a causal relation to pellagra, several cases of which had occurred in that vicinity recently, and a report was made concerning the more common species of fungi which were found therein.

One Press Bulletin, No. 18, *Apple Bitter Rot,* has been issued.

INCOMPLETE WORK.

In addition to the above work which may be regarded as completed, much other new work is under way.

Apple Diseases.—Several interesting apple diseases, some of them new, are still the subject of study.

Lettuce Experiments.—Work on lettuce sclerotiniose has been continued, following the suggestions indicated by our previous studies, which showed that hibernation of the fungus seems to be limited to the sclerotia. The lettuce bed was last year thoroughly infected with the disease. Our efforts this year have been entirely directed to the prevention of the formation of sclerotia, with the hope that within a year or two we may be able to demonstrate the possibility of completely eradicating the disease from an infected bed. Also an undescribed lettuce disease of very great destructiveness has been brought to our attention from Fayetteville and elsewhere. The bacteria causing this disease has been isolated. Artificial infection has been produced and we are now determining the identity of the organism, its relationship and its characters.

Sclerotinia on Clover.—A very serious clover disease caused by this fungus, close kin to that on the lettuce, has come to the laboratory. The causal fungus has been isolated and successful inoculations made.

Soil Bacteriology.—This work is being conducted jointly by the Biological and the Chemical Divisions. At present two main lines are under investigation, as follows:

1. Methods for the determination of Nitrification and Ammonification. This work embraces a trial of the efficiency of various methods to determine these factors.
2. Ammoniacal Nitrogen versus Nitrate Nitrogen. The fact that many of our soils are deficient in nitrifying power has raised the question whether nitrates are of great importance to plants or whether ammoniacal nitrogen may not be fully as acceptable to plants as nitrate nitrogen. To test this question, numerous experiments are under way under full chemical and bacteriological control.

BACTERIOLOGICAL SOIL SURVEY.

In order to ascertain whether the deficiency in nitrifying power, so marked in the neighborhood of Raleigh, is general throughout the State, it is planned to receive numerous samples of typical soils from all portions of the State and to determine their ammonifying and nitrifying powers, employing the methods devised by us and which are mentioned above.

In addition to the above major investigation, several other interesting observations have been made. For example, a serious outbreak of the *egg-plant wilt;* the occurrence of a very serious *maple-leaf disease* in Raleigh which seems to be due to a yeast; the occurrence of a *cotton-leaf* spot due to a species of *Phyllosticta,* possibly new; a very serious, widely spread, *sweet-potato disease,* possibly due to *Oospora,* which seems always to be present; the occurrence of the alga-like fungus *Rhodochytrium,* which seems to be everywhere on ragweed, though never collected on this plant heretofore and collected only once before in North America and only twice in the world.

Other interesting diseases which have come under our observation are a *fig rust;* a *privet disease* due to fungus attack upon the roots, resulting fatally to the plants; a peanut *Cercospora,* which is quite destructive; a *vetch Colletotrichum,* which seems to be new, and a *rot* of *tuberose bulbs,* which caused the loss of about 200,000 bulbs to one grower. This last disease has been found to be due to a species of *Penicillium.*

MELON AND TOBACCO WILTS.

Work has been continued on the lines of preceding years, looking to control of the melon and the tobacco wilts through the development of resistant varieties.

PLANT-DISEASE SURVEY.

This work is carried on in co-operation with the National Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants and to secure information concerning their distribution. The results of this work will be summarized and published later.

Several identifications of seeds, weeds and fungi have been made and a few bacteriological water examinations have been completed.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, several thousand pieces of mail matter have been sent out by this Division.

During the year, J. C. Temple, assistant in Soil Bacteriology, a most efficient worker, has resigned to assume charge of the Department of Soil Bacteriology at the Georgia Experiment Station, and has been succeeded by P. L. Gainey, who is doing able and conscientious work.

Respectfully submitted,

F. L. Stevens,
Biologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30:

During the year experiments have been conducted in feeding for profitable egg production, in breeding for increased egg yield, in determining the advisability of supplying moisture in incubators and of disinfecting incubators before each hatch. The studies in in- and line-breeding have been continued.

FEEDING EXPERIMENTS.

Feeding work this year has been largely along the line of comparing cotton-seed meal and meat meal as sources of protein for laying hens.

When this work was started during the summer of 1908 it was not known what effect cotton-seed meal would have on the health of the hens. All that was known was that for some of the larger animals it is a valuable feed, while for others it cannot be fed except in small quantities and for limited periods without detriment to the health of the animals.

In order to test this, it was fed to several pens of fowls for three months in quantities ranging from 10 to 20 per cent of the total ration. No bad effects to the health of the fowls resulted from feeding any of the rations.

On December 1st fourteen pens of fowls were used to continue this work; five of these were fed rations which contained cotton-seed meal; and nine on rations containing meat meal.

The meat meal used was much richer in protein than is usually found in products of this class, as analyses showed it to contain 86 per cent protein and 7 per cent fat. It was, however, deficient in ash when compared with animal meal and beef scrap, which are commonly used in poultry' feeding. These latter feeds contain more or less bone, which supplies the ash.

It had been thought that part of the benefit resulting from the feeding of protein from an animal source was due to the mineral matter generally found in these products, and as this element was lacking in the meat meal used, we added bone meal to some of the rations containing both meat meal and cotton-seed meal. Although these experiments have not been completed, it might be well to mention some of the points that the results seem thus far to indicate:

1. Fowls do not relish cotton-seed meal as well as meat meal, and therefore do not eat freely of mash containing cotton-seed meal.

2. Pullets fed on a cotton-seed meal ration do not develop as rapidly or start to lay as soon as those fed on a ration containing meat meal.

3. Hens have done better than pullets on rations containing cotton-seed meal.
4. The addition of bone meal to a meat-meal ration reduced the cost of egg production and increased the size of stock.
5. The addition of bone meal to cotton-seed meal ration did not reduce the cost of production, due probably to the small amount of cotton-seed meal mash eaten.

The results obtained even from the best rations show that if the farmer is to secure the greatest profit from his hens he must take full advantage of his ability to give his hens a good range on a green crop from which they can obtain a large part of their food at very small cost.

In order to determine if the farmer can profitably feed the more concentrated and higher priced feeds, such as meat meal and beef scrap, and, if so, in what proportion and at what time of the year, we propose to put out several pens of fowls on free range, so that different rations can be tested under conditions similar to what the farmer has.

BREEDING FOR INCREASED EGG PRODUCTION.

In this work the progress made has not been as great as had been hoped for. The plan generally recommended for the improvement of both animals and plants, of repeatedly selecting the best producers to breed from, does not appear to give as good results in egg production as in some other lines of work. In a great majority of cases it has been found that the daughters of our best layers are among the poorest layers. In three years' work along this line only one female has been found which has shown any marked power to transmit good laying qualities to her offspring. Neither this hen nor her daughters have been the heaviest layers of the flock, but better average results have been secured from this family than from any other.

From our experience it has been found that it is more necessary to know the breeding quality of our hens than their capacity to make a large yearly record, and that the best progress will be made by selecting individual proved breeders, and through the individual establishing families, rather than by a continued selection of the heaviest layers of indiscriminate breeding.

INBREEDING.

The work in inbreeding, as outlined in last year's report, has been continued. Five pullets from one of the best hens were selected from last year's breeding. Two of these were mated with their own sire, two with a cock of the same line of breeding, but not closely related, and one with a cock of an entirely different line of breeding.

INCUBATION.

The work started last year in testing the value of supplying moisture to the incubator and in disinfecting each incubator just before putting in eggs has been continued.

Disinfecting the eggs with a 10 per cent solution of zenoleum has also been tried. This solution was found to be too strong, as it injured the hatching quality of the eggs.

The use of a sand tray in the bottom of the incubator to supply moisture has given good results, the percentage of chicks which died in the shell being materially reduced. Some incubator operators have questioned the value of this method of supplying moisture in machines when the ventilation is from the top downward. By the use of hygrometers we found that the use of the sand tray raised the relative humidity an average about 10 per cent above that of similar machines in the same room without the sand tray.

Added moisture and disinfection are now being used in the general hatching work of the Station, and it is believed that the disinfection can be extended to the brooder as well with good results.

BROODING.

Both the fireless and heated brooders have been used with good results.

Good, strong, vigorous chickens can be raised in brooders without artificial heat, but for the first week they need more attention than do those reared in the heated brooder. Chicks do not learn to go back into the fireless brooder as quickly as they do in the heated ones, and if left to themselves are apt to stay outside and become chilled. On account of this extra care there is not so much saving in labor as some claim, but there is a very great saving in the cost of equipment necessary to raise the chicks in the fireless brooder, as any handyman can make the necessary box in a few minutes.

GENERAL WORK.

The demand for improved stock for breeding purposes and eggs for hatching continues to increase, this demand being about one-third greater than during the previous year.

The increased price of poultry and eggs, together with the awakening of the farmers to the fact that it pays to keep good stock, are largely responsible for this.

Along with this desire for better stock has come a demand for information as to the care and management of poultry, which has largely increased the correspondence of this Division.

Respectfully submitted,

J. S. Jeffrey,
Poultryman.

REPORT OF HORTICULTURIST.

The following is a report of the work of the Horticulturist for the year ending June 30:

DOUBLE FLOWER OF BLACKBERRY AND OF DEWBERRY.

Work on double flower or rosette has consumed most of the time of the Horticulturist during the year. A preliminary study of the trouble was made during the summers of 1907 and of 1908. The experimental work was started during the past spring.

Only a small amount of the double flower appeared in the Wilson blackberry plat this spring; this was expected, as the trouble is usually not very common until the plants are two or three years old. No double flower has appeared in the Lucretia dewberry plat.

During the spring, observations were made on 23 varieties of blackberries and on 14 varieties of dewberries. A careful study is also being made of the structure of the double flowers, including the rosette-like growth of the stems and leaves and also of the flowers themselves. The double flower, so far as has been observed, never produces any fruit. Many of the stamens are defective and the ovules and druplets do not develop. This work will be extended and continued during the coming year.

During June of the present season experiments were begun to determine what effect spraying, pruning, and picking off the leaves would have on the development of double flower.

SELF-STERILITY IN DEWBERRIES AND IN BLACKBERRIES.

The experimental part of this work was started this spring. About 500 flower clusters of different varieties of dewberries were covered with paper bags to determine what varieties will set fruit without cross-pollination. We are confining ourselves this year to the following eight varieties of dewberries: Austin, Chestnut, Cox, Manatee, Premo, Rogers, San Jacinto, and White. Some interesting and very decided results were obtained during the spring. This work will be continued.

A careful study will be made of the character of the flowers of the Premo dewberry, which seems to be notably self-sterile. This is to determine what really is responsible for the self-sterility, whether it is due to defective stamens or defective unfertile pollen or whether the pollen matures at the wrong time.

The Horticulturist recently published a Bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes. This publication has aroused much interest in this subject.

WORK WITH PLUMS.

Work was started during the spring to determine whether brown rot can be controlled in Japanese plums by thinning the fruit and spraying with the self-boiled lime-sulphur mixture.

Respectfully submitted,

F. C. Reimer,
Horticulturist.

REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the work carried on by the Animal Husbandry Division for the year ending June 30:

The experiment designed to determine the value of fermented cotton-seed meal for hogs has been completed and the results have been reported in Bulletin 200, Feeding Fermented Cotton-seed Meal to Hogs. The experiment is summarized as follows:

Corn alone proved to be an undesirable ration for growing hogs. causing small gains and unthrift. This condition was more marked. owing to the fact that the lot was closely penned, without pasture; yet the other lots, similarly confined, made relatively larger gains.

Fermented cotton-seed meal can be fed in small quantities for limited periods with good results. The results indicate that seventy-five to ninety days is the limit of satisfactory feeding. This would depend, however, on the age and condition of the hogs, the supplementary feeds, and the proportion of cotton-seed meal fed.

Lot 3, fed a combination of corn and cotton-seed meal, in the proportion of four to one, made larger and cheaper gains for the first ninety days than the lot similarly fed on corn and linseed meal. This would seem to indicate that, when possible, cotton-seed meal should be used, since it contains a larger percentage of protein and sells for about one-fourth less per ton than linseed meal.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to 75-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of seventy-five to ninety days.

The feeding of the four lots of hogs during the first period was more profitable when one part of cotton-seed meal was added to the ration of four parts corn than when corn alone or corn and linseed meal in combination were fed. In the case of linseed meal, however. the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately $28 per ton, the results show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. While Lots 2, 3 and 4 had a somewhat larger ration than Lot 1, the larger gains during the first period were sufficient to considerably overbalance this factor.

The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by North Carolina farmers.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is the cheapest commercial concentrate for the Southern farmer and hence should not be entirely ignored in swine production.

An experiment to determine the value of cotton-seed meal as a feed for horses and mules is in progress. In this it is designed to determine the following:

1. The possibility of using cotton-seed meal as a supplementary feed to corn for work horses and mules.
2. The amounts and conditions under which it could be most satisfactorily fed.
3. The economy of the ration.
4. The effect on the health and condition of the animal.

The experiment was started April 6, 1908, and the meal has been fed continuously to the present. The results secured indicate that cotton-seed meal can be made a valuable adjunct to the ordinary ration for horses and mules, when fed properly. From 1 to 1½ pounds per animal per day have been fed with apparent satisfaction. The meal is most satisfactorily fed, however, when thoroughly incorporated with corn and cob meal, bran, brewers' grain, or some other feed of like consistency. It is not possible to feed the meal in conjunction with ear-corn with satisfaction. To feed cotton-seed meal satisfactorily the feed which forms the basis of the ration should be of such a nature as to permit of the meal being mixed with it thoroughly.

Close observations made on the work-stock, both in the barn and in the field, have revealed no apparent harmful results. This experiment will be continued to study other phases of the problem.

At the beginning of the year an investigation was started to determine the cause of the harmful effects noted when cotton-seed meal is fed to hogs and to isolate the toxin, if such it is.

This work is being carried on jointly by the Animal Husbandry, Veterinary and Chemical Divisions. Hogs and guinea pigs are being used in the work. The use of guinea pigs makes it possible to use in the investigations various parts of cotton-seed meal prepared chemically, which would not be feasible were large hogs used exclusively. Although definite results cannot be given at this time, the work is progressing satisfactorily. The work has gradually increased, as new phases of the work developed.

Along with this work, grazing experiments with swine are being conducted to determine the value of the many forage crops that grow well in North Carolina. The principal crops used so far are cowpeas, soy beans, crimson clover, sweet potatoes, peanuts, rape, Canada field peas, oats, and rye.

During the year a comparatively large number of inquiries have come to the Animal Husbandman regarding feeding, breeding, and management of live stock.

On the Station farm a number of improvements have been made. The equipment for carrying on the swine experiments is fairly complete. Additional farrowing pens, colony houses, a dipping tank, and pastures have been provided.

Respectfully submitted,

R. S. CURTIS,

Animal Husbandman.

REPORT OF DAIRY HUSBANDMAN.

The main work in this Division consisted of a study of the relative economy of narrow and medium rations for cows under North Carolina conditions. This work was prompted by the relative cheapness of cotton-seed meal, which suggested the wisdom of feeding larger quantities of this material than has hitherto been the custom. Cotton-seed meal is very rich in protein, and rations containing a large amount of it will have a very narrow nutritive ratio—much narrower than is ordinarily recommended for cattle feeding.

The narrow ration fed consisted of five parts cotton-seed meal, four parts wheat bran, three parts corn meal and 50 pounds of corn silage. This ration had a nutritive ratio of 1:4. The medium ration was the same as the narrow, except that 2½ pounds of cotton-seed meal were replaced by 2½ pounds of corn meal, giving this ration a nutritive ratio of 1:5.7.

The results of this experiment were strongly in favor of the narrow ration, but it was thought best to duplicate the experiment in order to allow more positive conclusions to be drawn with reference to the wisdom and practicability of feeding a narrow ration.

The duplicate of the above experiment is now in progress.

A Bulletin on the Manufacture and Marketing of Cottage Cheese, Skimmilk-Buttermilk and Ice-cream was published during the year.

The facilities of the Dairy Division are excellent for the prosecution of effective Station work next year, and five new lines of investigations are already in progress.

Respectfully submitted,
John Michels,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

The following is a brief statement of the work of the Entomological Division for the year ending June 30:

An investigation of the life-history and habits of the harlequin cabbage bug (terrapin bug), *Murgantia histrionica,* commenced in April, 1908, and was continued throughout most of the year. (A full account of this investigation, together with remedial suggestions, will be found among the Scientific Papers in this Annual Report, under the headings, "Suppression of Terrapin Bugs" and "Spring Destruction of Terrapin Bugs.")

Some attention has been given to a study of the life-history of the cabbage webworm, *Hellula undalis.*

The common little red-house ant, *Monomorium pharaonis,* became very abundant last August in the agricultural building, and an attempt was made to eradicate them, or at least to devise some means of preventing their presence in undesirable places. For nearly four weeks this work was continued with partial success, by collecting thousands of the ants on sweetened baits and by attempting to attract them to poison mixtures. The sweetened baits served to trap thousands of ants, but the poison baits were of little if any value.

It was demonstrated that ants may be kept off laboratory tables, desks, shelves, etc., by the use of a saturated solution of bichloride of mercury, one application being effective for several weeks, except for an occasional stray individual. Any tape, made by soaking strips of cotton cloth in the solution, may be tied around the legs of tables, chairs, etc., and serves to repel the ants for a considerable time.

The corn weevil problem, mentioned in my last report, has been conducted mainly along the line of fumigation. Some field observations have shown that corn may become infested as early as August, while standing in the field. The fumigation experiments have shown that the usually recommended remedy, carbon bisulphide, is not effective under ordinary farm conditions.

The fumes of burning sulphur were tested in the spring of 1908 and again during the past winter. The results proved this to be an effective remedy for killing corn weevils, but it was found to be impractical because it affected the germinating power of the corn; even a smaller amount of sulphur fumes than was necessary to kill the weevils materially reduced the germination of the corn.

Some work was carried on during February with good results in combating San José scale by means of the lime-sulphur wash. The orchard in which the studies were made, as it was badly infested, serves as a good illustration of the benefit derived from thorough spraying with this wash. The apple crop this season has been large and has been kept quite free from codling-moth worms, *Carpocapsa pomonella,* by two sprayings just after the blooming period with a mixture of 3 pounds of arsenate of lead in 50 gallons of Bordeaux mixture, the latter being used to prevent leaf diseases.

Press Bulletins on Fall Destruction of Terrapin Bugs and Spring Destruction of Terrapin Bugs, and a regular Bulletin on Corn Weevils and Other Grain Insects have been prepared by the Entomologist during the year.

Respectfully submitted,
R. I. SMITH,
Entomologist.

REPORT OF VETERINARIAN.

I beg to submit a report of the work of the Veterinary Division for the year ending June 30:

The major part of the work has been given over to a study of the toxic effects of cotton-seed meal when fed to swine and guinea pigs. Both of these have been found to be quite susceptible to the ill effects of such feeding.

Daily observations have been made on nearly all of the animals fed, to determine, if possible, specific symptoms of the derangement produced by cotton-seed meal. With a number of the swine daily records were kept of weights, temperatures, pulsations and respirations. At frequent intervals blood readings were made, estimating amount of total solids, numbers of red and white corpuscles, the per cent of hemoglobin and specific gravity.

Post-mortem examinations have been made of all animals which died of cotton-seed meal feeding. In a number of instances weights were taken of various organs to compare with total weight, also portions of tissues were preserved for sectioning and for microscopical examination.

During the first half of the year work was carried on with the Bacteriological Division in an attempt to determine some of the poisons and their causes developing in milk. Samples of milk were inoculated with dirt and germs from various sources, and after a lapse of sufficient time for abundant germ growth the infected milk was injected into guinea pigs. Daily observations were taken, and upon the death of pigs post-mortem examinations and attempts to isolate germs from the blood were made.

During the year there were a large number of inquiries concerning hog cholera, and at one of the larger winter resorts, where the disease had just developed, we undertook to control its ravages by the production and use of hog-cholera serum, as advised by the National Bureau of Animal Industry. The owner had lost during the previous year nearly all of his swine except a few which recovered from the disease, and these afforded material necessary for preparation of the serum. The hogs were isolated as far as possible to delay or prevent infection until the serum could be produced, requiring some three weeks, according to the method pursued. Nearly one-fourth of the 200 head were sick or dead by this time, but after the injections of serum were made very few others became sick. As a curative agent after the symptoms of the disease developed it was found to be of little if any value, such as other investigators have observed, but its effect in preventing the trouble in those not infected was very marked. Some co-operative work with the State Department of Agriculture is being undertaken to further prove the efficiency of this serum in preventing and controlling hog cholera.

Internal parasites, being extremely common in pigs and shoats reaching the local market, turpentine and thymol are being compared as to their efficacy in freeing grossly infested shoats of worms.

A number of specimens have been received at the laboratory for examination, both bacteriologically and pathologically.

A marked increase in the number of inquiries concerning diseases in general has been noted.

Respectfully submitted,
G. A. ROBERTS,
Veterinarian.

RECEIPTS AND EXPENSES.

North Carolina Agricultural Experiment Station in Account with the United States Appropriations, 1908-1909.

Dr.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1909, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	11,000.00

Cr.	*Hatch Fund.*	*Adams Fund.*
By Salaries	$7,313.88	$8,272.76
Labor	2,203.45	1,181.09
Publications	662.56	....
Postage and stationery	294.12	....
Freight and express	84.29	....
Heat, light, water and power	39.78	....
Chemical supplies	....	409.91
Seeds, plants and sundry supplies	565.33	223.34
Fertilizers	519.57	....
Feeding stuffs	901.47	....
Library	23.98	83.40
Tools, implements and machinery	373.65	....
Furniture and fixtures	530.40	....
Scientific apparatus	....	171.75
Live stock	464.00	389.90
Traveling expenses	258.52	....
Contingent expenses	15.00	....
Buildings and land	750.00	267.85
Total	$15,000.00	$11,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1909; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $26,000, and the corresponding disbursements $26,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)
J. T. Ellington,
O. L. Clark,
T. T. Ballenger,
Auditors.

(Seal.)

Attest: A. F. Bowen, *Custodian.*

SCIENTIFIC PAPERS.

EFFECTS OF DIFFERENT FERTILIZING MATERIALS UPON THE MATURITY OF COTTON.

By C. B. WILLIAMS.

In fertilizer experiments which have been conducted at the North Carolina Station farm on a poor soil of the cecil sandy-loam type, deficient in organic matter, during the past five or six years, it has been observed frequently that the same variety of cotton planted on the same kind of soil and worked by identical methods matured differently on different plats, it being quite marked in some cases. From results secured at the Red Springs, Edgecombe, and Iredell Test Farms of the North Carolina State Department of Agriculture during two years, the writer made the same observations. These data and the deductions therefrom were published in September (1906) Bulletin of that Department. As results have been secured from coarse sandy, fine sandy loam, sandy-clay loam and tenacious clay soils for two to five years, it will be noted that the observations made and results secured have embraced many years' data and have covered a wide range of soils located under quite varying climatic conditions.

At the Station something like thirty tests have been conducted in which fertilizing materials were combined in different proportions and used in different quantities per acre, and in all cases a hastening of maturity was effected. On the unfertilized plats in all tests during all the years it has been found that in most cases the larger the yield the greater the combined percentage of seed cotton open at the first two pickings. At the end of the second picking there was but little difference, relatively, between the percentages of seed cotton open on those plats which received different quantities of fertilizer and different fertilizer combinations; but on these there was something like 50 per cent more open, as an average, than was on the plats which received no fertilizer application, but which had otherwise been subjected to the same treatment as the fertilizer plats. From the unfertilized plats about 75 per cent of the cotton was picked at third and fourth pickings; while those receiving an application of commercial fertilizer only had about 60 per cent of the crop left to open at these pickings, except in the case of the plat which received a mixture of 48 pounds of manure salt and 78 pounds of dried blood per acre, which had, on an average, 68.6 per cent. As showing the seasonal effect, especially of drouth, it will be found that by contrasting the results secured during the years 1904 (with an excess of .91 inch of rain during the months of August, September, October, and November) with those of 1905 (which had 3.45 inches deficiency from the normal for the months of August, September, October, and November, taken together, and 1.52 inches below normal for the month of November), it was found that the average percentage of total crop open on four unfertilized plats at the fourth picking was much greater in 1905 than in 1904.

EFFECTS OF CARRIERS OF PHOSPHORIC ACID.

As carriers of phosphoric acid, acid phosphate, basic slag and finely ground phosphate rock have been tested, and all have been found to hasten the maturity of cotton, as shown by the percentage of seed cotton open at first and second pickings. In fact, the hastening of the maturity was decidedly more marked from phosphatic fertilizing materials than from carriers of potash and nitrogen tried. Increasing the quantity of phosphoric acid derived from acid phosphate with normal amounts of potash and nitrogen was attended by a gradual increase in the percentage of total seed cotton open at the first picking.

Acid Phosphate.—When 196 pounds of acid phosphate was added to an application consisting of a mixture of 48 pounds of manure salt and 78 pounds of dried blood, there was almost 13 percentage increase in seed cotton open of total crop at the first picking and more than 7 percentage increase at the end of the second picking. This application also gave 22 at the first picking and 12 per cent at the end of second picking more of the total yield open than was secured from the adjoining plat which had received no fertilizer treatment.

Basic Slag.—Basic slag was found to hasten maturity even more than acid phosphate, as was shown by practically one-half of the cotton being open at the first picking on the plat which received an application of this material in connection with normal quantities (48 pounds of manure salt and 78 pounds of dried blood) of manure salt and dried blood. On the plat to which phosphoric acid, in connection with normal application of potash and nitrogen, was supplied from acid phosphate, it was found that about 12½ per cent less of total cotton opened at the first picking than did on the plat from which the phosphoric acid in equal quantities was furnished from basic slag under the same conditions. When this latter material was applied in the drill in connection with a ton of stable manure per acre, the effects upon hastening maturity were markedly reduced.

Phosphate Rock.—Where high-grade finely ground phosphate rock as a carrier of phosphoric acid was used at the rate of 274 pounds per acre (four times normal phosphoric acid) in connection with a ton of stable manure, and both were applied in the drill, it was noted that the percentage of total seed cotton open at the first picking was about 35 per cent and at the end of the second more than 20 per cent greater than on an unfertilized plat adjacent.

EFFECT OF CARRIERS OF NITROGEN.

Carriers of nitrogen used in fertilization, such as dried blood, nitrate of soda, etc., have been found to hasten the maturity of cotton, but not anyways near to the extent that carriers of phosphoric acid do. The effect of the common nitrogen carriers seems to be felt only at the first picking, as there is no evidence from results secured that they affected the percentage of total crop open at the second picking. When used with normal amounts of acid phosphate and manure salt, increasing the amount of blood, as the carrier of nitrogen, was attended by an increase in the percentage of total crop open at the first picking, up to 200 to 300 pounds per acre of the blood.

Dried Blood and Nitrate of Soda.—When 78 pounds of high-grade dried blood was added to normal quantities of acid phosphate (196 pounds) and manure salt as a fertilizer application, the percentage of total crop open at the first picking was increased 3.3 per cent. Where in normal applications the amount of blood was reduced by one-half and an amount of nitrate of soda, equivalent in content of nitrogen to the reduction, was used as a side dressing and applied early in July, it was observed that the percentage of total crop open at the first picking was greater, generally, than in those cases where the whole of the normal application of nitrogen was derived from dried blood. When one-fifth of the nitrogen was derived from nitrate of soda and the remaining four-fifths came from dried blood, there was a rather marked increase in the percentage of total crop open at the first picking. When the nitrogen, in connection with normal quantities of potash and phosphoric acid, was derived from blood, one-half of which was applied at planting and the remainder reserved as a side dressing and applied early in July, it was observed that a larger percentage of total crop opened at the first picking than did where nitrate of soda was used as the carrier of nitrogen and which was divided and applied in the same way.

Cotton Seed and Stable Manure.—With cotton seed as a carrier of nitrogen and applied in the drill at planting, the effect upon maturity was about the same as where dried blood was used, while in the case of stable manure there was a material increase in the percentage of total crop open at the first picking, but showed no difference at the second picking.

EFFECT OF CARRIERS OF POTASH.

Manure salt was the only potash-bearing salt used. It was found, when used at the rate of 48 pounds per acre, to hasten the maturity of cotton but slightly. To be sure, the amount here used was quite small, and marked results were not expected where so small a quantity of any fertilizer material was used. Where one-half, twice, and thrice this quantity of manure salt was used in connection with normal amounts of phosphoric acid and potash, it was found that as the proportion of potash increased the percentage of total crop open at the first picking gradually diminished, except for the year 1907, August of which had about three inches less rainfall than normal.

EFFECTS OF LIME.

Slaked lime applied alone during the spring of 1903 and 1907 did not seem to increase the maturity of cotton in any year, as shown by the percentages open at the first and second pickings being about the same as for the unfertilized land; but, when used in connection with a normal application of a mixture of acid phosphate, manure salt, and dried blood, a marked hastening in maturity was noted. At the first picking, on an average, the addition of air-slaked lime at the rate of 1,000 pounds per acre every four years to a normal application of a complete fertilizer, resulted in an increase of more than 11 per cent of the total crop maturing than of the cotton planted on the plat receiving a normal application alone.

EFFECT OF DIFFERENT QUANTITIES.

It has been observed for the types of soil studied that increasing the amount of the application per acre of a fertilizer analyzing 7 per cent available phosphoric acid, 2½ per cent nitrogen, and 2½ per cent potash, from

200 to 800 or 1,200 pounds, that such an increase was accompanied generally by an increase in the percentage of total seed cotton of whole crop open at the first picking.

From the data used in preparing this paper, the following tentative deductions may be made relative to the influence of fertilizer upon the growth of cotton:

1. Fertilization with ordinary applications of commercial fertilizers hastens maturity.

2. Sandy and sandy-loam soils, whether fertilized or unfertilized, yield larger percentages of total cotton open at the first two pickings combined than do red-clay soils.

3. Heavy phosphoric acid ($N P_3 K$) fertilization on sandy and sandy-loam soils and medium heavy ($N P_2 K$) applications of phosphoric acid from basic slag have produced the largest percentages of total seed cotton open at the first picking.

4. Normal ($N P K$) fertilization yields on both sandy and red-clay soils a larger percentage open at the first picking than high nitrogen ($N_3 P K$) applications.

5. High nitrogen ($N_3 P K$) applications generally yielded on all types of soil studied larger percentages of total yield open at the first picking than high potash ($N P K_3$) applications.

6. Air-slaked lime alone does not hasten maturity, but when used in connection with commercial fertilizers it augments their influence in hastening maturity, as shown by percentage of cotton open at first picking.

SOME FACTS CONCERNING THOSE CHARACTERS OF THE CORN PLANT ASSOCIATED WITH YIELD AND FACTORS WHICH INFLUENCE THEM.

By C. B. WILLIAMS and W. C. ETHERIDGE.

With corn, as with other crops, yield is determined by environment and by certain characteristics which the individual plants may possess. Without a favorable climate, good soil, and thorough tillage, no strain of corn can produce maximum yields any more than, with these supplied, can the greatest yields be secured where seed bred and selected in the most intelligent manner are not used. In consideration of these facts, it is deemed not inappropriate at this time to consider somewhat in detail some of those characters of the corn plant which seem to be associated intimately with high yielding capacity. The deductions made are largely from data secured with some sixty to seventy varieties of corn, many of them grown each under four different conditions—two of fertilization and two of distancing the hills in the rows.

I. CHARACTERS ASSOCIATED WITH YIELD.

Prolificacy in Ears.—As prolificacy is influenced by soil and climatic conditions, increasing the yield of any variety is usually attended by an increase in its prolificacy within narrow limits; and the larger the yield in grain of a variety, the larger the percentage of ear of total plant, the heavier the grain and the less pounds of ear-corn required to shell a bushel.

In variety tests on the Station farm during the past six years, as it has been found to be a pretty general rule that those which have averaged the largest yields of grain per acre were those possessing a decidedly strong tendency to produce more than one ear per stalk, it would seem to be safe to infer that the prolificacy of stalks in ears should be given prime consideration in selecting seed corn. In the Station tests it has been found that Sanders' Improved, a fairly prolific variety, has yielded as an average of five years 6.8 bushels more of shelled corn per acre than Holt's Strawberry, a good one-eared variety; while Biggs' Seven-ear, another prolific variety, has outyielded Holt's Strawberry 4.4 bushels as an average of three years' tests. Ordinarily, for the better grade of improved farming lands, it is not felt that it would be wise to select seed from stalks bearing more than two ears. It is believed that the richer the land on which the corn is to be planted the greater the prolificacy in ears that may be selected for with profit. On the poorer grades of land it is suggested that, until its yielding capacity has been increased, the best one-eared varieties be grown. Too great a prolificacy of corn to be planted on poor land may be a positive detriment to yield. The tendency of such seed will be to produce a large number of ears; and as the limited supply of available plant food contained in the soil will run quite low towards the latter part of the growth of the plants, there will usually be a large number of shoots and nubbins produced and very few ears; while, on the other hand, a one-eared variety might have given fairly good-size ears under the conditions; certainly it would in all probability have done better. It might be stated in this connection that, where these conditions of soil obtain, it is thought that time might be put to better advantage in growing on it soil-improving crops, such as cowpeas and clover, and defer planting it to corn until it has been considerably improved in producing capacity. It is not felt that corn can be raised profitably on very poor land.

Percentage of Grain.—Although it is essential for any variety to possess the characteristic of producing a high percentage of grain to ear for it to attain its maximum yielding capacity, yet, as other factors, such as prolificacy, size of ears, source of seed, etc., enter, the largest yields need not necessarily be expected from those varieties possessing the highest percentage of grain. As a matter of fact, the largest yields by varieties tested at the Station farm during the past five years have been secured from those which produce a medium percentage of grain; but this is not because this is an unessential of the highest possible yields, but rather seems to be due to the fact that varieties possessing the highest percentages of grain have been bred and selected largely for this quality alone, while other characteristics that might have contributed to the yields were seemingly left out of consideration to a large extent in the establishment of these varieties. Increasing the size of the ear of any variety, it has been observed, is generally attended by an increase in the percentage of grain to ear, although to some extent this is modified by season.

The best yielding varieties have been found to bear ears which shell on an average of 80 to 87 per cent grain. With the same variety there is a seasonal variation of a fraction of a per cent to 2 to 4 per cent, or even more.

Size of Ears.—Large-eared varieties usually have a relatively low percentage of grain to cob, and are, as a rule, less productive of shelled corn per stalk than the more prolific varieties. Although, taking everything into consideration, where corn is gathered by hand, as is done in many portions of the South, it will usually be a little easier and slightly cheaper to gather and handle the same acreage of large-eared corn than of corn with smaller ears, when the yield of shelled corn per acre for both are the same, yet, quite frequently, from a financial standpoint, it will be better for the farmer to use seed of a variety possessing a relatively small ear, because of the greatly increased yield of grain per acre that would result from the use of such seed. Within reasonable limits, it should not be so much the size of the ears that should govern in the selection of a variety for seed purposes as the persistency of the seed of the variety to withstand adverse conditions and to produce large yields of shelled corn per stalk and hence per acre. However, within the same variety it will usually be advisable to choose for seed those ears, other characteristics being equal, that are of the average or slightly above the average in size for the variety.

The size of the ear of a variety is not determined solely by heredity, but is greatly influenced by climate, season, soil fertilization, cultivation, etc.; for the more favorable these conditions are for the growth of the plants, the larger and heavier will the ears and kernels produced be at maturity; and the more unfavorable these conditions are, the smaller they will grow. In other words, if seed of the same variety were planted during the same year on both rich bottom and ordinary upland soils, it would be found at maturity, with a favorable season, that the corn grown in the bottom had not only produced a larger yield and greater number of ears per stalk, but had also borne considerably larger ears, and it would generally be easy for one who is at all familiar with ear types of different varieties to determine by general appearances whether a given ear had been produced on rich land or not.

It will be better to use seed of a variety having medium small ears with poorly shaped kernels in preference to one with large, well-shaped ears possessing well-formed kernels, if the former produces, under the same conditions of season, soil, and cultivation, greatly increased yields over the latter, notwithstanding the fact that it may be a little less expensive to house the latter, because the net profit resulting from the former would be much greater.

By using a variety with a strongly fixed prepotency to high yield of shelled corn per stalk—the great desideratum, after all—the size and shape of the ear and its kernels may be materially improved within a few years, through careful seed selection, with a resulting tendency to further increased yields over the original stock. It should be borne in mind clearly, however, that by developing larger and better-shaped ears and kernels of any variety, through seed selection, persistently practiced through a number of years, that only two of the many characters that contribute to high yields are improved.

Height of Ears and Stalks.—It has been found that the best yielding varieties were those which possessed a medium to tall stalk and were those which have their ears at a medium height. The varieties which had the lowest stalks and ears were those seed of which have come from the corn-growing States of the Northwest. The ears should be attached a little below the center of the stalks. Varieties which make too large a growth of stalks are generally late in maturing and are therefore far more likely to be caught by early frost in the fall than those that make a relatively small or medium growth of stalk.

Date of Maturity.—As a general thing, those varieties which mature earliest are the smallest yielders of both grain and stover, while those producing most per acre are medium to late maturing. Other things being equal, earliness in maturity of not only corn, but all other crops, is at a sacrifice of yield, as earliness and high yield are antagonistic characters, if a favorable growing season is afforded for the maturity of the later maturing varieties. Usually, also, earliness is accompanied by a high percentage of ear to stover; but this ratio is more or less influenced by season, soil, fertilization, breeding and selection. It might be stated here that with many crops, however, earliness is more essential than heavy yields; especially is this so with trucking crops, for if they do not reach maturity early in the season the best prices are not obtained. Where for any reason the season for growth is short, the best of the early varieties will give the largest yields under the conditions, but the yield will be smaller generally than would have been produced by the best of the medium and late maturing varieties had the season been sufficiently long for their full development.

II. DIFFERENT DISTANCING OF HILLS IN EQUIDISTANT ROWS UNDER DIFFERENT DEGREES OF FERTILIZATION.

Effect Upon Yield.—The optimum distancing for yield of corn, as with other crops, is governed by variety, season, soil, fertilization, cultivation, etc. For the same soil, the more favorable the season, fertilization, and cultivation, the closer, within limits, the planting may be done with profit, especially so with the prolific varieties. To illustrate specifically the effects of fertilization under local conditions which embody principles of wide application, it was found that as an average of the yields of 68 varieties, planting at 20 inches in the row produced 3.8 bushels more shelled corn and 563 pounds of stover per acre on highly manured land than did spacing the hills 30 inches in the row; while on the same land which did not receive but 300 pounds of commercial fertilizer per acre the yield of grain and stover was practically identical at both distancing (20 and 30 inches) and were but little more than one-half those obtained from the highly manured plats of the same acreage. With the highly manured plats, 76.1 per cent of the varieties yield most shelled corn per acre at 20-inch spacing of the hills as against 30 inches, and those which did not follow this rule were all of one-eared type. In the case of stover, 86.6 per cent of the varieties yielded most where the stalks stood 20 inches in the row on the highly manured plats. On the better manured plats, 85.1 per cent of the varieties yielded a greater value of total products (grain and stover) at 20-inch spacing in the rows. With varieties receiving an application of (cow) manure supplemented by 300 pounds of commercial fertilizer, the value of total products was $5.29 more per acre where the stalks were 20 inches than where they were 30 inches; while on the same land which received only 300 pounds of commercial fertilizer per acre the difference was, on an average, not but 23 cents, which was in favor of 20-inch distancing in the rows. From the above, therefore, it is observed that increasing the productivity of the soil by a fairly liberal broadcast coating of (cow) manure and fertilizer was accompanied by materially increased yields, over 30-inch spacing, by thinning the stalks to 20 inches, while under ordinarily poor fertilization there was practically no difference between a spacing of 20 and 30 inches of the hills in the rows, which emphasizes the importance of closer planting as the fertility of the land is increased.

Results in these experiments were secured from 68 varieties of corn grown in 4-foot rows during 1908 on poor land of the cecil sandy-loam type which would not normally without fertilization yield more than 12 to 14 bushels per acre. The land was treated in two sets in different degrees of fertilization. On one set of plats, which will be termed the "highly manured" set, 16 tons of a high-grade cow manure (the cows had been fed on cotton-seed meal and wheat bran, and no bedding was in the manure), supplemented by an application of 300 pounds per acre at planting of a fertilizer analyzing 7 per cent available phosphoric acid, 3 per cent nitrogen, and 1½ per cent potash was used; while the other set received only 300 pounds of commercial fertilizer per acre of the grade given above. This set in the discussion that follows will be called the "poorly fertilized" one.

Effect Upon Size of Ears.—Under heavy manuring, stalks which were 30 inches in the row produced ears, on an average, which were .37 inch longer and .12 inch greater in circumference than those grown on stalks standing 20 inches apart; while on the poorly fertilized plats the ears were .44 inch longer and .16 inch greater in circumference at 30-inch than those grown at 20-inch spacing of the stalks. The average length and circumference of the ears on the more highly manured land were .99 and .46 inch respectively greater than where the 68 varieties were grown on the poorly fertilized plats. On the highly manured land 84.6 and 68.2 per cent and on the poorly fertilized plats 79.1 and 76.1 per cent of the varieties produced ears longer and circumference of same greater respectively at a spacing of 30 inches. As an average of all the varieties, it required 122 ears to shell a bushel from hills thinned to 30 inches and 131 ears at 20 inches on the highly manured plats; while for the poorly fertilized corn, it required 166 ears at 30-inch-grown and 200 ears of that grown 20 inches in the row. On the poorly fertilized plats it required an average of 56 ears more to shell a bushell of corn than it did where the corn was produced on the better land. On the highly manured plats 72.7 per cent of the varieties required a larger number of ears to shell a bushel where the corn was grown 20 inches apart in the rows; while on the poorly fertilized plats 83.3 per cent of the varieties required most at the same distancing. On the highly manured plats it will be observed that a 20-inch distancing of the hills gave the largest yields, while stalks spaced 30 inches produced the largest and longest ears. Both higher fertilization and greater distancing between hills increased the length and circumference of the ears of two-thirds to three-quarters of all the varieties under experiment.

Effect Upon Height of Stalks and Ears.—On the highly manured plats the height of the stalks and ears were 2.30 and 1.60 inches higher respectively at a spacing of 20 inches between the stalks than at 30 inches; while on the poorly fertilized plats the stalks and their ears were 5.50 and 1.70 inches higher above the ground respectively at 30 inches. The average height of the stalks and ears under better manuring were 11.35 and 6.40 inches higher respectively than those grown on the poorly fertilized plats. Of the stalks and their ears of the 68 varieties, 67.2 and 68.7 per cent at 30 inches, and 83.8 and 69.1 per cent at 20 inches, were highest on the heavily manured and poorly fertilized plats respectively. It would seem, then, from these data that in the presence of limited quantities of plant-food in the soil an increase in the distance between stalks from 20 to 30 inches of corn planted in 4-foot rows leads to the production of a taller growth of stalks and higher attachment of ears above ground; while with the same soil fairly well supplied with plant-food from (cow) manure and fertilizer for the immediate needs of the plants an increase in the thickness of planting from 30 to 20 inches is attended by the growth of higher stalks and ears.

Effect Upon the Number of Ears and Amount of Shelled Corn per Stalk.—On the highly manured plats there were for all the varieties taken together .11 more ear per stalk at 30 inches than at 20 inches spacing of the hills in the row, and on the plats receiving only 300 pounds of commercial fertilizer .10 more of an ear on an average at 30 than at 20 inches. Contributing to these data 91.0 per cent of the varieties on the highly manured land and 86.8 per cent on the poorly fertilized plats produced most at the respective favorable distancings. The average difference between the highly and poorly fertilized plats was .15 more of an ear per stalk on the former than on the latter. The corn under better fertilization produced 27 per cent more shelled corn per bearing stalk at 30-inch distancing than at 20 inches; while that grown on land poorly fertilized, an increase of 41 per cent was secured in favor of the former distancing, which indicates that in the presence of limited quantities of plant-food a slight increase in the amount of space per plant is attended by a much greater increase in yield of grain per stalk than is secured on land which is more highly manured. The highly manured plats, as an average of both distancing, produced .148 pound shelled corn per bearing stalk, or an increase of 68.4 per cent more shelled corn per bearing stalk than was produced on the plats receiving 300 pounds of commercial fertilizer alone. It will be observed that increasing the distance between the hills and the fertility of the land were attended by a larger number of ears per stalk and by a marked increase in the quantity of shelled corn per bearing stalk.

Effect Upon Maturity and Stand.—The two distancing of hills studied did not seem to affect differently to any great extent the growth of the plants up to the tasseling and silking stages, yet the weight of evidence is that closer spacing of the stalks retarded the maturity by about one day, on an average. The corn on the highly manured plats tasseled and silked from three to four days earlier than on those receiving an application of commercial fertilizer alone. Better fertilization seems to lead to a more perfect stand, as is evidenced by the varieties planted on the plats which received an application of (cow) manure and 300 pounds of commercial fertilizer being 2.56 per cent better than that from seed of the same varieties planted in the same manner on the same type of soil which received only an application of commercial fertilizer.

Effect Upon the Production of Suckers.—On the more highly fertilized plats 9.48 per cent at 30 inches and 6.13 per cent of the stalks produced suckers at 20-inch spacing of hills in the row; while on the poorly fertilized plats 6.15 per cent produced suckers at 30 inches and 2.87 per cent at 20 inches. Suckers, therefore, are increased in number both by increasing the distance of the hills apart and by the addition of more plant-food to the soil. It has also been observed repeatedly that under the same conditions some varieties produce many times more suckers than do others, hence the production of these is a varietal characteristic which is influenced by fertilization, spacing of plants and other environmental factors.

Effect Upon Barrenness.—By decreasing the distance between hills from .30 to 20 inches on the manured plats the percentage of barren stalks was increased from 1.73 to 3.42 per cent, while on the poorly fertilized corn it was raised from 5.26 to 10.73 per cent. It will be noticed from these data that for both the sets the percentage of stalks barren was doubled by a decrease in the distancing of the hills in the row by 10 inches, and that the corn on the poorly fertilized plats was affected with more than three times the percentage of barrenness that prevailed on the plats receiving (cow) manure and commercial fertilizer. Therefore, barrenness seems to be decreased both by an increase in the distance between hills in the row and by heavier and more favorable fertilization.

VARIATION OF FUNGI DUE TO ENVIRONMENT.[1]

BY F. L. STEVENS AND J. G. HALL.

The effects of environment, climatic condition, soil fertility, .the presence of unusual chemicals, the water relation and what not upon the form and characters of seed plants are well known to the plant physiologist, and have been the subjects of numerous studies. These factors are even utilized by the practical man to bring about desired variation.

That fungi vary similarly will not be doubted by any who have had to do with fungi in artificial cultures. The kind and degree of such variation, we dare say, will be a surprise to any who have made special study of this subject.

While our knowledge of the seed plants, owing to man's long acquaintance with them, their larger size and comparative stability is considerable, yet even with them the limiting of genera, species, varieties, etc., presents difficulty, if we may judge from the rich literature upon phanerogamic taxonomy. The fungi, because of their immense number of species, variety of forms, minuteness, paucity of distinguishing characters, complexity of life-history (mostly unknown) peculiar biologic host relations (almost entirely unknown), and because of man's short acquaintance with them and their unknown but apparently vast range of variability, present as yet baffling problems of relationship and classification.

The object of the present article is to call attention to the kind and degree of environmental variation found in a few species of fungi that have been studied by the authors during the past four or five years and in some instances to analyze the causes of these variations to the end that the factor of environmental variation may be more clearly recognized as a problem of mycological taxonomy.

We shall consider these variations under the causes that produce them.

I. DENSITY OF COLONIES.

Septoria petroselini Desm. var. *apii* Br. and Cav., from celery.

This fungus, when plated so that the spores lay thinly scattered, produced colonies which were ultimately black, from 1 to 2 mm. in diameter, with pycnidia of normal character; if plated so that the spores lay in large numbers per square centimeter, it produced colonies which reached a size of only about .5 mm. and became ultimately black, containing ordinary pycnidia, bearing spores in the normal way. When plated so that there were still more spores per square centimeter, the colonies never became black and no pycnidia were produced; but to the contrary, multitudes of spores were borne uncovered, in clumps upon simple hyphæ.

Septoria lycopersici Speg., from tomato.

Spores from pure culture were plated in 4 per cent pea agar in various dilutions.

---

[1] Read in part at the Baltimore meeting of the Botanical Society of America, December, 1908, and published in the *Botanical Gazette* 48 (1909).

One plate developed 5 to 6 colonies per square millimeter and each colony proceeded to normal pycnidial development. Another plate developed 21 to 23 colonies per square millimeter and all proceeded to form naked conidia with no indication of pycnidia. Portions of these two plates are represented by photomicrographs (Figs. 1 and 2). Drawings of the naked spores showing the detail of their formation are given in Fig. 3. Occasionally plates with as many as 30 colonies per square millimeter were found with both pycnidia and naked spores.

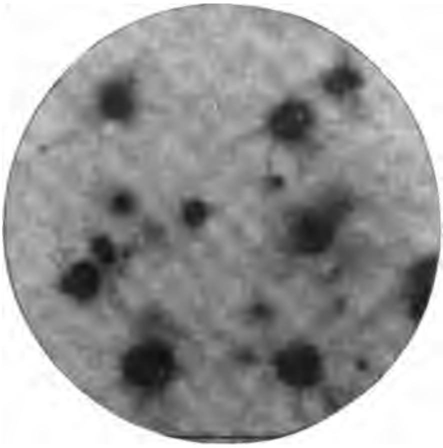


FIG. 1.—*Septoria Lycopersici* Speg., showing formation of normal pycnidia on portion of thinly sown plate culture.

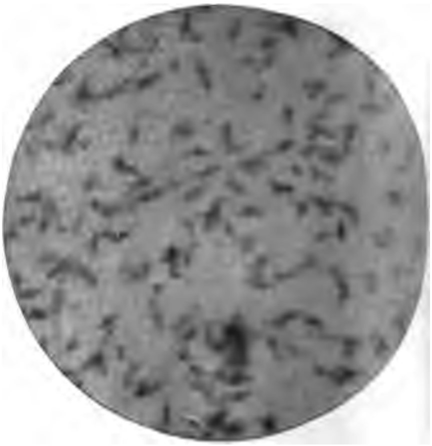


FIG. 2.—*Septoria Lycopersici* Speg., showing sence of pycnidia on thickly sown portion of culture; magnification same as in Fig. 1.

Pycnidia not visible at the fifth day may be well formed by the sixth day and extrude masses of pink spores about the twenty-first day. Occasionally pycnidia are well developed on the fourth day. When naked spores develop they normally appear a few days later than do pycnidia, *e. g.*, a plate thinly sown on January 12, 1907, gave many pycnidia on January 15, while a thickly sown plate, under conditions otherwise precisely parallel, did not give naked spores until January 22.

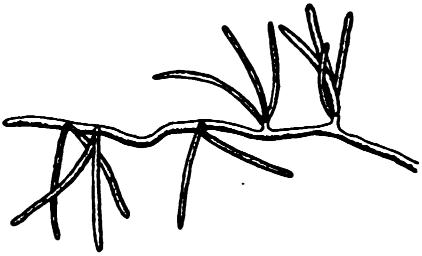


FIG. 3.—Mode of formation of naked spores under influence of crowded culture.

This septoria forms a typical determinate colony, *i. e.*, even with unlimited room, it proceeds only to a certain size of development.

Septoria consimilis E. & M., from lettuce.

When sown thinly colonies reached a size of 2 to 3 mm. in diameter; when sown thickly they became no more than .2 mm. in diameter. There was no interference with color development or formation of pycnidia by thick sowing with this species.

With two of these septorias, thick plating, other conditions being the same, so changed their character that not only would the species be considered as different, but the fungus would be shifted from the *Sphaeropsidales* to the *Hyphomycetales* (Hyplaesa of Saccardo).

A similar change of habit is well known in the genus *Fusarium*, which in culture, crowded or not, often abandons acervulus formation, thus changing its systematic position from the *Tuberculariaceae* to the *Mucedinaceae*. The genera *Colletotrichum* and *Gloeosporum* similarly abandon acervulus formation and thus suffer still greater taxonomic disturbance by moving from the *Melanconiales* to the *Hyphomycetales*.

Ascochyta chrysanthemi Stevens, from chrysanthemum.

This fungus was plated January 12, 1907. Myriads of pycnidia were present four days later; thick plating caused no inhibition of pycnidial formation, no naked spores and no constant effect upon the number of pycnidia produced.

Volutella fructi S. & H., from apple.

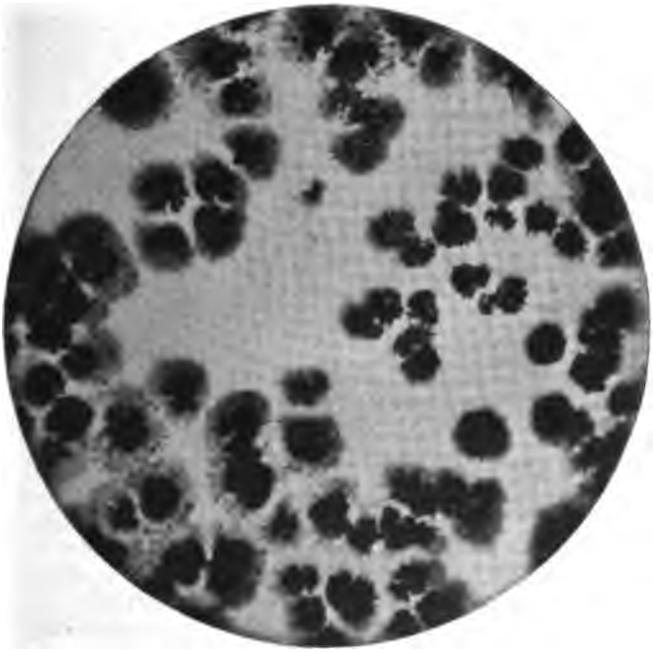


FIG. 4.—*Volutella fructi* S. and H., showing colonies on thinly sown plate culture.

Thinly sown, the colonies were large, of indeterminate growth, showing dark centers with pale borders (Fig. 4); thickly sown, growth was inhibited and their characters lost. (Fig. 5.)

Spermoedia paspali Fries, from *paspalum*.

Spores of this fungus were sown January 19, 1907, in plates giving colony densities of 90, 54, 30, 14 and 1 per square mm.

At all of these densities germination was practically 100 per cent and growth proceeded equally in all plates during the early stages. On February

11 it was noted that all colonies which came nearly in contact were sporing. Growth then stopped. In the plates bearing only one spore per square millimeter the colonies continued to enlarge slowly and to produce many spores in the central portion, though remaining white, not attaining the usual yellow color. Deep colonies appeared like the superficial, but bore no spores. On February 7 the colonies on thin plates (1 per square millimeter) had attained a diameter of 1.5 mm. Some of those colonies transferred to tubes continued to enlarge, became tubercular, and developed a yellow center 3 or 4 mm. in diameter. The whole colony often reached 1 cm. in diameter. Sister colonies left in the plate (1 per square millimeter) failed to so develop, and it is evident that at even this density normal development is not attained

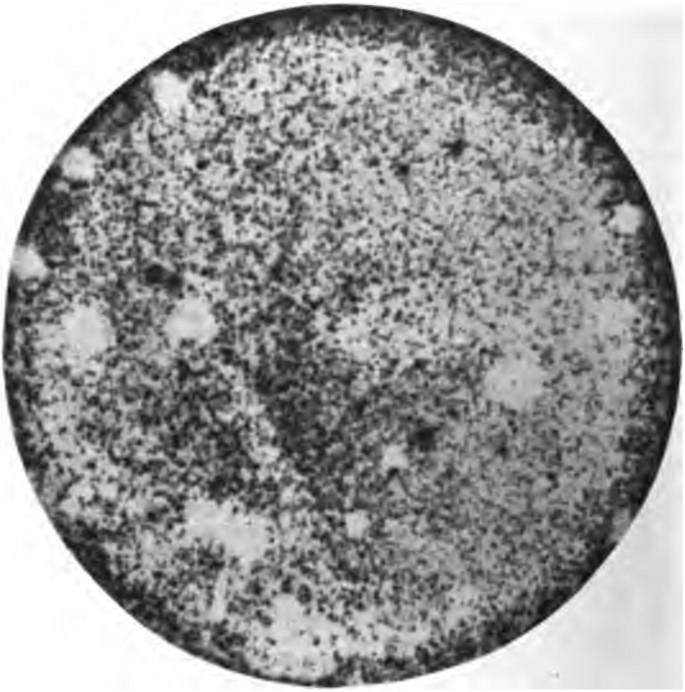


FIG. 5.—*Volutella fructi* S. and H., showing effect of thick sowing.

The colony is indeterminate in growth and in plates its size is limited by the presence of adjacent colonies.

SUMMARY REGARDING THE DENSITY FACTOR.

This factor produces different effects with the different species. It may inhibit pycnidial formation, resulting in naked spores; it may cause failure to develop color; it may limit the size of the colony; or it may be without effect.

There are many paired species of the imperfect fungi agreeing closely, except in the presence or absence of one character. These pairs often occur upon the same host, *e. g.*, *Septoria lycopersici* Speg. and a *Cylindrosporium* on the tomato, and *Cylindrosporium Chrysanthemi* E. & D. and *Septoria Chrysanthemi* Cav. on the cultivated chrysanthemum.[1]

Many other instances could be cited.

The lack of fixity of such a structure as even the pycnidum throws doubt upon the validity of such species as these and indicates the necessity of close comparative study.

II. DENSITY OF MYCELIUM: ZONE FORMATION.

The formation of concentric zones is by many fungi one of the most conspicuous characters shown in cultures. These zones may be due to any one of many structural characters of the colony; to varying density of spore massing; pycnidia grouping, mycelial branching, color, etc. It is a frequent prenomenon in nature in the fairy rings of the toad stools, the concentric markings of many leaf spots, fruit rots, etc. These effects have been attributed to

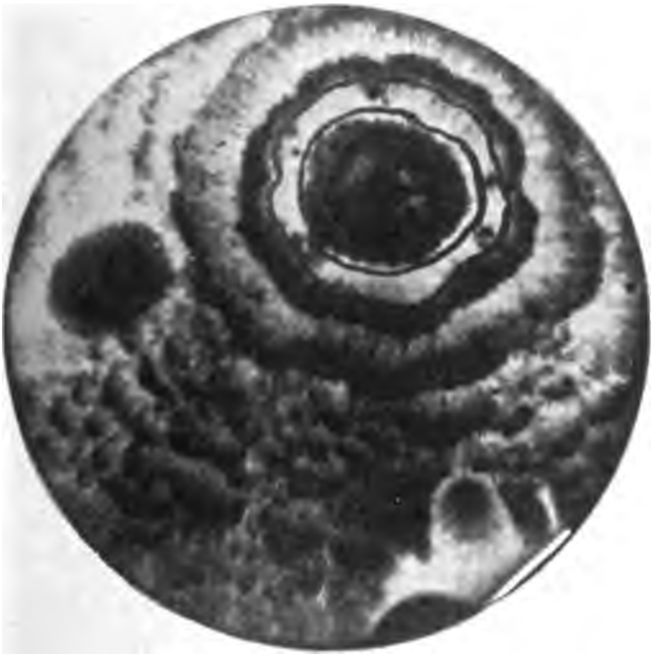


FIG. 6.—*Ascochyta Chrysanthemi* Stevens; plate culture showing that the formation of zones is not coincident with diurnal changes; ink marks show growth for three consecutive days.

---

[1] VOGLINO, Diseases of cultivated chrysanthemums, Malpighia 15 (1902), 329–341. E. S. R. 14, 777.

[1] HALSTED, Chrysanthemum leaf spot, American Florist, 10 (1894), No. 333, 263. E. S. R. 6, 311.

[1] BEACH, Leaf spot of chrysanthemum, N. Y. State Sta. Rpt., 1892, 557–560.

[1] HALSTED, Report of fungus disease of plants, N. J. Sta. Rpt., 1891, 233–340.

[1] Sacc. Syll. Fung. 11, 542, Nos. 3497, 3498, 3757. Tubeuf and Smith, Diseases of Plants, 478. Year-Book U. S. Dept. Agr., 1906, 507. Geneva Sta. Rpt., 14, 529. N. J. Sta. Rpt., 1894, 361.

various causal agencies: to light relation,[1] to nutrients,[2] to agencies other than light, probably food, and to resting periods and to mycelial crowding.[3]

Ascochyta chrysanthemi Stevens.

With the fungus in question the fact that the zones are not due to light or temperature relations is apparent from the fact that they do not coincide with the fluctuations of these two factors (Fig. 6). In the colony shown, which is that of a plate culture kept at room temperature, there was daily change from warm to cool, light to dark, yet the number of rings does not coincide with the number of these changes; moreover, zones were produced in precisely the same way on plates kept constantly in the dark as in plates kept all of the time in the light, and still the same on plates kept three days in the dark and then three days in the light.

Microscopic examination shows that with this fungus the dark zone is due to a larger number of mycelial filaments, the light zone to a smaller number of threads, as is shown diagrammatically in Fig. 7. It seems that with this fungus the dense crowding of the filaments resulting from their repeated branching inhibits growth either by the products of metabolism or exhaustion of nutriment. There is then a period of quiescence, followed by onward growth of a few scattered hyphæ. As these outgrowing hyphæ reach beyond the inhibiting influence, they branch repeatedly until a new dense zone is formed. This process is repeated indefinitely. The rapidity of succession of zones is dependent solely upon the relation which rapidity of branching bears to rapidity of increase in length. Slow lineal growth and much branching gives many narrow zones; rapid lineal growth with infrequent branching causes broad zones.

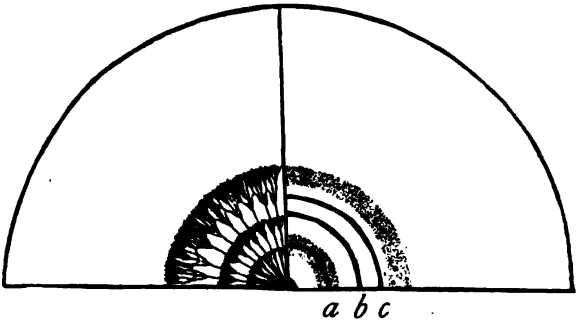


FIG. 7.—Diagram showing, at right, the zones (stippled) and diurnal marks; at left, theoretical expression of cause of zonation.

Sclerotinia Libertiana Fckl., from lettuce.

Zonal sclerotial formation is exhibited by this fungus. (Fig. 8.) That this phenomenon may be attributed to crowding of the mycelium is indicated by the fact that adjacent colonies form more sclerotia at their points of contact. (Fig. 9.)

---

[1] MOLZ, "Ueber die Bedingungen der Entstehung der durch *Sclerotinia fructigena* erzeugten." Schwarzfaule der Aepfel. Cent. f. Bak. II. Ab. 17, 175.

HUTCHINSON, "Ueber Form und Bau der Kalonieen niederer Pilze." Cent. f. Bak. II, Ab. 17, 602. Also

HEDGECOCK, Zonation in Artificial culture of Cephalothecium and other fungi. Ann. Rpt. 17, Mo. Bot. Gard., 1906.

[2] MILBURN, Ueber Aenderungen der Farben bei Pilzen und Bakterien. Cent. f. Bak. Ab. II, 13, 257.

[3] ISTVANFFI, Etudes Microbiologiques et mycologiques sur le rot gris de la vigne. Am. de l'Institut Cent. Ampel. Roy. Hongrois, 1905, 183.

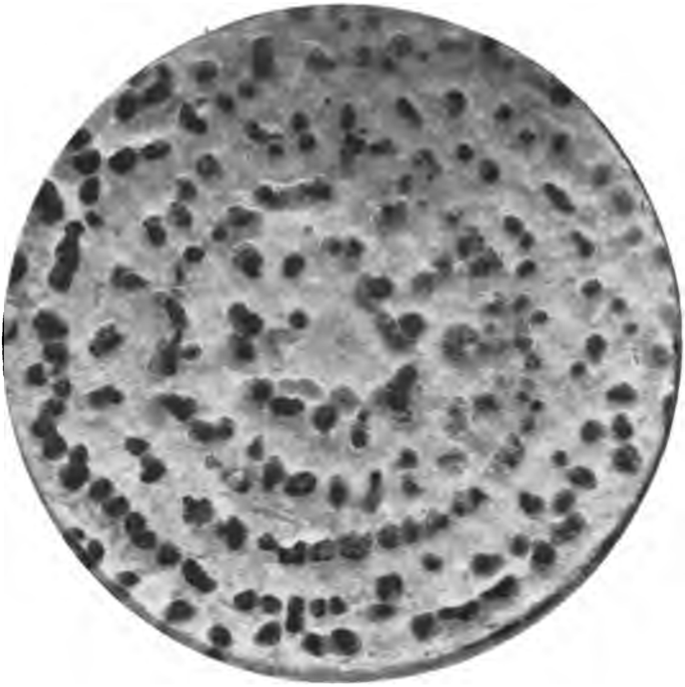


Fig. 8.—*Sclerotinia Libertiana* Fckl., showing zonal formation of sclerotia on corn meal culture.

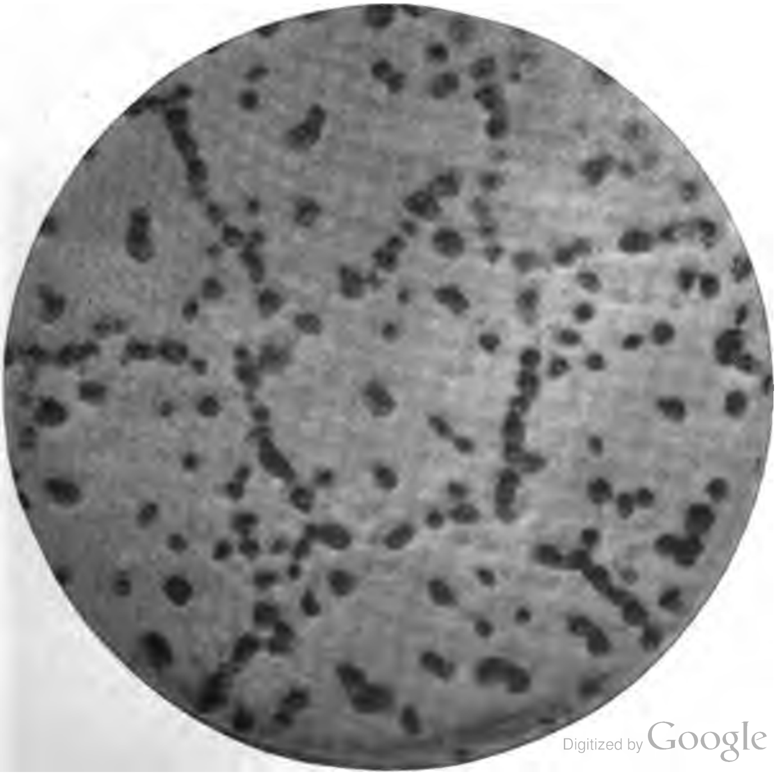


Fig. 9.—*Sclerotinia Libertiana* Fckl., showing the formation of sclerotia in greater abundance where adjacent colonies come in contact.

SUMMARY REGARDING DENSITY OF MYCELIUM.

Zone formation in *Ascochyta Chrysanthemi* is due to crowding of mycelium, not to light or heat relation. A similar conclusion was reached by Istvanffi (Istvanffi lc.) regarding the very striking zones shown by *Sclerotinia.* The same causes may apply also with *Daldinia concentrica* and many other fungi of similar structure.

III. CHEMICAL RELATIONS.

Chemical relations have been studied with eleven fungi, the fungus being usually grown in agar with varying nutrients added. Occasionally other media were used. A chemical base agar (cba) was made of the following proportion:

Water	1,000	grams.
Di-potassium phosphate	2.5	grams.
Calcium chloride	.01	gram.
Magnesium sulphate	.01	gram.
Sodium chloride	2.5	grams.
Potassium sulphate	2.	grams.
Agar	15.	grams.

To 100 cc. of this chemical base agar were added the following materials singly or in varying combinations:

Ammonium lactate	.5	gram.
Sodium asparaginate	.25	gram.
Glucose	1.	gram.
Starch	1.	gram.

The tests were usually made in both plate and tube cultures.

Volutella fructi S. and H., from apple.

This fungus, when sown thin, forms large indeterminate colonies, often with numerous scattered tubercular blotches (Fig. 10).

On pure agar and cba the colonies were pale; mycelium hyaline; black tubercles very sparse.

On pea agar black tubercles were much more abundant, otherwise as on pure agar.

On cba+sodium asparaginate black tubercles were still more numerous.

On cba+sodium asparaginate+starch black tubercles were more numerous than in any of the above, and the colony was black (Fig. 11).

On cba+sodium asparaginate+glucose black tubercles were still more numerous, so many as to be contiguous, and the whole colony was densely black.

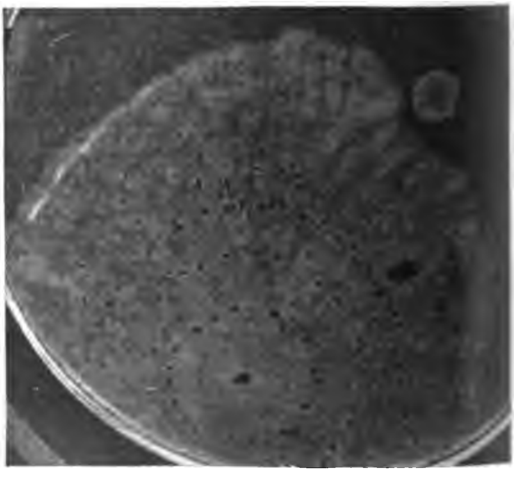


FIG. 10.—*Volutella fructi* S. and H.; colony on pea agar showing tubercular blotches, some of them in concentric rings; mycelium nearly hyaline, due to lack of carbohydrates.

On gelatinized starch+Uschinsky's solution the mycelium was black, and some digestion of the starch was observed.

On none of the above media were spores formed, but on sterilized apple twigs spores were produced in abundance.

The differences here noted upon these different media are sufficient to alter entirely the general appearance and to shift the fungus from the Tuberculariaciae-Dematiae to the Tuberculariaciae-Mucedinae.

Coniothyrium Fuckelii Sacc., from apple.

This fungus when growing upon a medium rich in starch becomes black in its peripheral layer. Glucose fails to produce the same result. The mycelium hyaline when on pea agar, but tawny on apple agar.

Septoria petroselini var. *apii*, from celery.

This fungus fails to produce naked spores when sown thickly on celery agar, though it does so under similar conditions when upon lettuce agar.

Colletotrichum carica S. and H., from fig.

This fungus upon the different media used showed striking differences in number or setae, varying from none to abundant; number of spores varying from few to many; color, varying from pale to almost black.

On cba+growth was scant; acervuli small, setae absent.

Fig. 11.—*Volutella fructi* S. and H.; two black colonies upon cba + sodium asparaginate + starch.

On cba+ammonium lactate and cba+sodium asparaginate growth was about as in cba, except that numerous black setae were present.

On cba+ammonium lactate+starch the acervuli were larger, more numerous, with numerous large black setae.

On cba+sodium asparaginate+glucose, black setae were numerous.

On cba+sodium asparaginate+ammonium lactate there were a few setae.

Epicoccus sp. indet, from apple agar in Petri dishes.

This fungus on pure agar and cba was colorless. On cba+starch or cba+glucose there was much richer mycelial development which, moreover, took on a rich yellow color that in spots turned to pink. Sometimes black spots developed on the first of these media, but not upon the second. This fungus shows strikingly the differentiating value of starch and glucose for fungus culture.

Upon apple agar still another character developed, a rich golden color of the abundant fluccose matted aerial hyphæ. This reaction is fully as striking as the familiar rose color produced by a certain species of Fusarium.[1]

With this fungus we have absence of color in agar and cba, but rich coloring of varying hues in the presence of carbohydrates and upon apple agar.

---

[1] Bessey, Ueber die Bedingungen der Farbbildung bei Fusarium, Inaug. Diss. Halle., 1904.

Phyllosticta sp. indet. from apple agar in Petri dishes.

This fungus grew faster on agar than on cba, formed pycnidia sparsely on agar and not at all on cba.

With sodium asparaginate added the mycelium becomes very dense, with considerable aerial development, remains colorless and produces few pycnidia, and these visible only with the two-third objective. The presence of glucose led to exceedingly profuse pycnidial development, while on starch the growth was as with cba+sodium asparaginate, showing again the ability to utilize glucose, but not starch.

Alternaria sp. indet, from Lawson carnation.

This fungus, the cause of an apparently undescribed carnation disease which will be the subject of a subsequent paper, was isolated during October, 1908. There was striking difference in the color of the colony upon different media, varying from merely hyaline to dense black. The size and color of the spores was also so modified as to give much more than what is usually regarded as a specific difference.

On pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, and upon cba+ammonium lactate+sodium asparaginate, the mycelium was colorless and the colony correspondingly colorless, while upon cba+sodium asparaginate+starch and cba+sodium asparaginate+glucose the mycelium was very dark, more profuse, more freely branched, and the colony therefore of an entirely different aspect.

Spore formation proceeded sparingly, though evenly and regularly, upon pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, cba+sodium asparaginate+ammonium lactate; but very abundantly upon cba+sodium asparaginate+starch and upon cba+sodium asparaginate+glucose. Here the sodium asparaginate seems not to furnish the carbon in sufficiently available form, though starch or glucose do so to nearly equal extent.

The size, color and septation of the spores were also greatly influenced by the medium.

From carnation-agar plates the spores measured from 16 to 52 mu long by 6 to 13 mu thick, bearing from none to three longitudinal septa and from 3 to 7 transverse septa, while from the live carnation leaf the spores were from 26 to 123 mu long by 10 to 20 mu thick, bearing from 1 to 9 or often numerous longitudinal septa and from 3 to 15 transverse septa. It is seen that the spores are approximately twice as long, twice as thick, of darker color and with many more septa in each direction upon the natural medium than upon the carnation agar, differences which would ordinarily be regarded as clearly of specific rank.

Alternaria Brassicæ (Berk.) Sacc., from collard.

This fungus made hyaline mycelium in cba and cba+sodium asparaginate: black mycelium in cba+sodium asparaginate+glucose and in cba+sodium asparaginate+starch, starch producing by far the most pronounced effect.

Digestion of the starch grains, somewhat in advance of the tips of the oncoming fungus threads, produced a clear zone surrounding each colony in the starch-bearing plates.

Ascochyta Chrysanthemi Stevens.

This fungus was grown in the usual media with no significant effects, except that the fungus did not digest the starch grains afforded in the medium.

A deposit of great thickness around mycelial threads was made in the case of certain media and not in others, as has already been noted.[1]

In some instances culture at a high temperature occasioned this same response.

SUMMARY OF CHEMICAL RELATIONS.

The most striking response to chemicals is in color, which so far as observed was invariably heightened by the presence of chemicals bearing carbon in available form, the form of available carbon varying for different fungi. Some fungi, possessing ability to digest starch, can utilize this as a source, while to others the carbon of starch is inaccessible. Special unknown chemicals in apple add vivid colors to fungi otherwise hyaline. Some chemicals also promote or inhibit spore formation. Some inhibit or promote growth of setae, and some even alter the size, color and septation of spores. Milburn, working under Klebs (Milburn, lc.), has also noted pronounced effects of chemicals upon the color of fungi. The difference in color effects produced by different fungi under the same conditions and with the same fungus under different conditions is also noted by Bessey.[2]

No correlation is noted between rapidity of lineal growth and nutritive value of the medium. In many instances most rapid lineal growth occurred in what was surely the poorest medium. Very poor media suffice in many cases also for spore formation, while rich media often result in cessation of spore formation.

Colletotrichum Lindemuthianum, sometimes with setae, often without, has long been of questionable generic position. The same is true of several other species of this genus. *Alternaria Brassicæ* and *Macrosporium Brassicæ* agree closely except as to presence or absence of catenulate spores.[3]

Variation of this kind is probably due to variation in chemical composition of the supporting medium, *e. g.*, change in sugar content as ripening proceeds, acting in such way as to give the fungus the appearance of belonging to one genus when upon the green sugar-free fruit, to another genus as the starch gives place to sugar as the fruit ripens.

IV. LIGHT RELATION.

The absence of material effect of light upon lineal growth with these species of fungi is shown in Table I.

---

[1] Bot. Gaz., 44, 1907, 241.

[2] Bessey, lc.

[3] A. *Brassicæ* Hyphae brevis conidia 60–80 x 14–18, septae 6–8.
M. *Brassicæ* Hyphae obsoletis conidia 50–60 x 12–14, septae 5–11.

TABLE I.—*Relation of Light to Growth.*

Figures express growth in millimeters. The cultures marked "alternate" were kept several days in light and several days in dark; L=light, D=dark. Inoculated December 8, 1908.

Date of Observation.	Condition of Light.								
	On Macrosporium Brassicæ.			On Phyllosticta sp. indet.			On Ascochyta Chrysanthemi.		
	In Light.	In Alternate Light and Dark.	In Darkness.	In Light.	In Alternate Light and Dark.	In Darkness.	In Light.	In Alternate Light and Dark.	In Darkness.
December 9..	Germ	Germ L	Germ	0	0 L	0	0	2 L	0
December 10..	1	1 L	1	Germ	Germ L	Germ	Germ	3 L	6
December 12..	6	6 L	6	4	4 L	4	4	12 L	12
December 13..	9	10 L	9	7	7 L	6	12	16 L	14
December 14..	13	12 D	11	10	10 D	7	15	20 D	18
December 15..	16	15 D	15	13	13 D	10	17	25 D	22
December 16..	17	17 D	17	14	13 D	13	25	30 D	25
December 17..	23	23 L	21	16	16 L	16	33	37 L	31
December 18..	26	26 L	29	20	18 L	19	39	39 L	37
December 19..	28	28 L	29	23	20 L	20	41	45 L	37

Ascochyta Chrysanthemi Stevens. The growth is more floccose in darkness.

Phyllosticta sp. indet. This fungus forms its pycnidia in beautiful concentric rings when in open room, *i. e.*, alternate light and darkness, but in continuous darkness they were irregularly scattered. Culture No. 35 made concentric rings when in the light and failed to do so when moved to darkness. Cultures kept in the open room lay down rudiments of pycnidia mainly during the night, and it is probable that light exerts enough inhibiting influence on pycnidial development to give a growth predominance during the day and a fructifying predominance during the night.[1]

Alternaria Brassicæ (Berk.) Sacc. With this fungus the end of each day's growth, evening, marks the edge of a zone. The zone thus marked is intensified during the succeeding twenty-four hours by color changes. While zones are formed to some extent in continued darkness, they are more pronounced in the room condition.

SUMMARY OF LIGHT RELATION.

Light exerts little or no effect upon lineal growth with these fungi. It appears to exert an inhibiting influence on pycnidial development and in some instances is the cause of zonation in colonies.

V. UNKNOWN FACTORS.

Ascochyta Chrysanthemi Stevens.

This fungus frequently exhibited differences in character along different radii of the same colony, the conditions of medium, thickness of sowing, humidity, etc., being apparently identical. Fig. 12 shows such a colony. Along the radius *a*—*a* at *b* the colony bore pycnidia abundantly, and the mycelial progeny of this strain extending to the periphery of the colony was rich in pycnidia, while most other radii of the colony were sterile or nearly so. Transfers were made from the point *c* (sterile) and *d* (pycnidial) to fresh plates. The sterile mycelium produced a colony which through its early days was sterile. As it aged it formed a few large pale pycnidia. The fertile strain produced a fertile colony with very numerous though small pycnidia. Transfers made again from these two strains resulted in a complete reversal of character, the fertile becoming sterile and the sterile becoming fertile. No explanation of this suggests itself.

---

[1] Hedgecock, 1c.

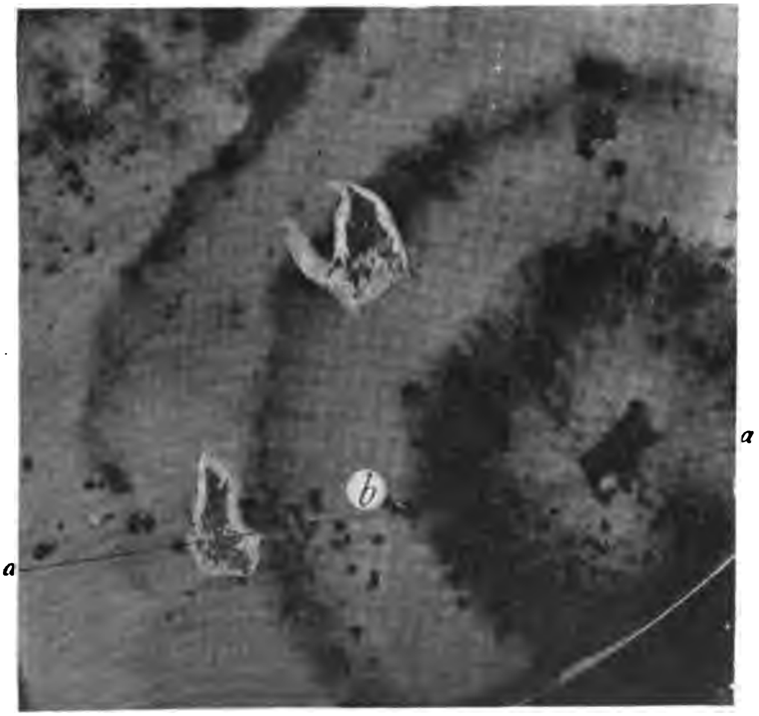


FIG. 12.—*Ascochyta Chrysanthemi* Stevens, showing abundant pycnidia on radius *a–a*, at point *b*, and paucity of pycnidia elsewhere.

When this fungus was plated from a suspension of spores two types of colony developed corresponding to the two strains mentioned above. The first "type of few pycnidia" developed a copious aerial mycelium of a loose floccose nature, extended regularly in all directions and was long devoid of pycnidia. When the pycnidia did form they were few, large and superficial (Fig. 13). The second "type of many pycnidia" had little or no aerial mycelium, all the mycelium being either immersed or of strict growth; was roughly circular in colony, not regularly so as in first type, and small, irregular, mostly immersed pycnidia were formed in myriads throughout the colony. (See Fig. 14.) These two types of colony appeared on the same plates which were inoculated with spores from the same pycnidium, therefore developed in th same nutrient condition, humidity, temperature, etc. Depth of planting is no the cause of these differences, since flooding the plate with an extra tu

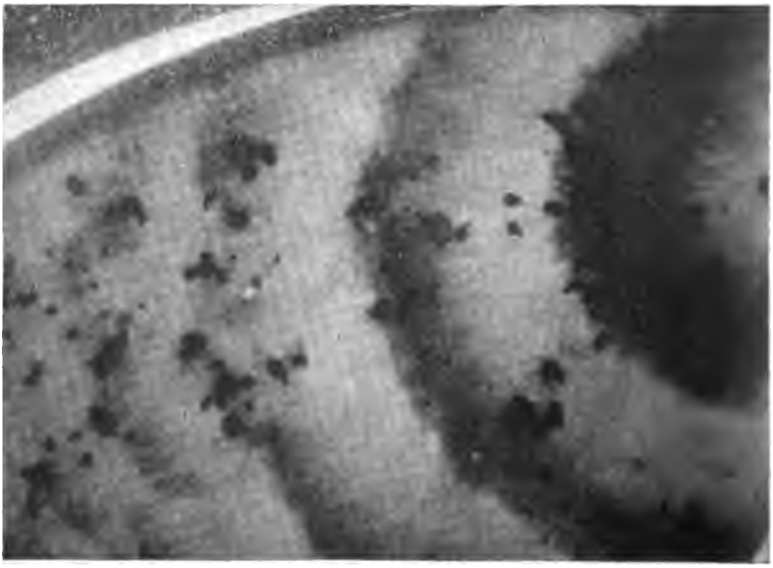


FIG. 13.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing few pycnidia; cf. Fig. 14.

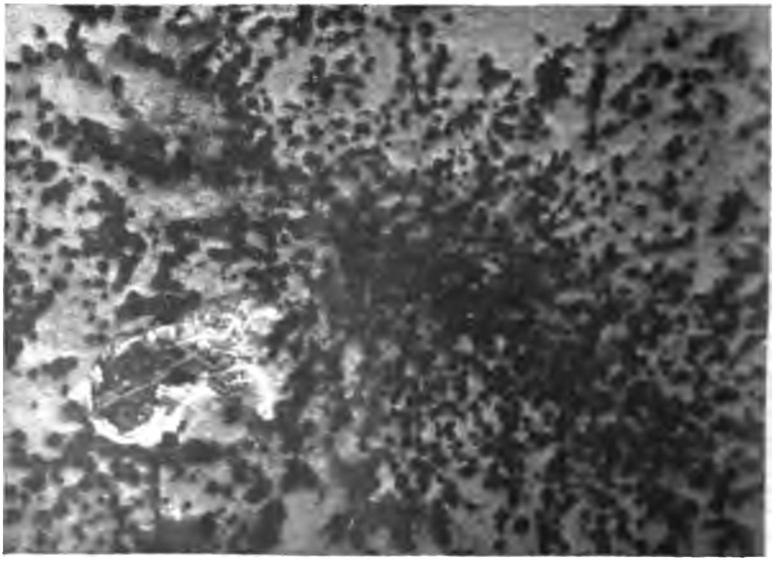


FIG. 14.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing many pycnidia. cf. Fig. 13.

of agar after the agar first plated had set. did not change the proportion of the two types. Nor did sowing in such way that the spores were at the bottom rather than at the top of the agar change results. There was a marked tendency of colonies of both types of the fungus to become more productive of large pycnidia where two different colonies approach each other, suggesting that there might be needed a co-operation of two diverse strains in order to form a pycnidium; that the strains of few pycnidia lacked the requisite individuals, and that the strains of many pycnidia had more than one individual to the colony. To test this, colonies were traced from the earliest development, resulting in clear evidence that in some instances a colony developed from a single spore was one with few pycnidia; in other instances a single spore produced a colony of many pycnidia.

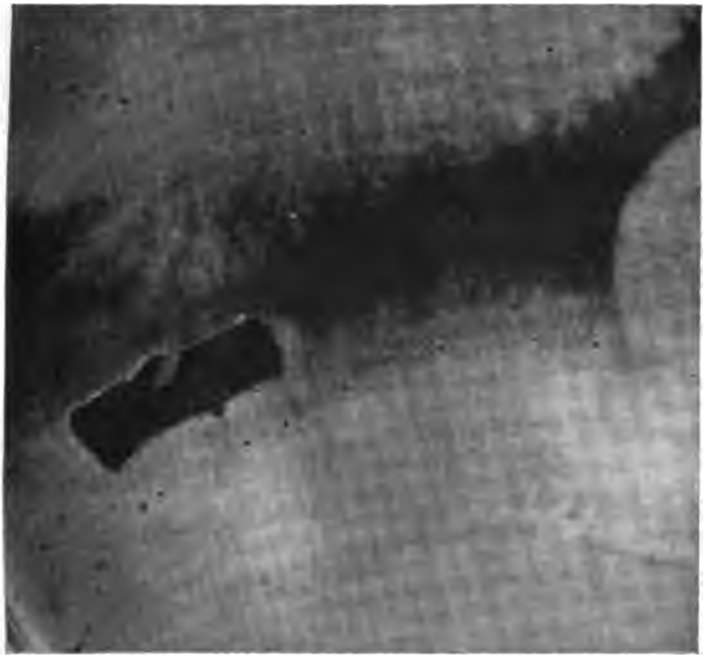


FIG. 15.—*Coniothyrium Fuckelii* Sacc.; portions of two colonies showing circles of pycnidia near margins.

Coniothyrium Fuckelii Sacc., from apple.

In one instance this fungus, which rarely fruited, made pycnidia in almost perfect circles near the margins of each colony on the plate. (See Fig. 15.)

These variations are inexplicable and remind one of the mysterious change from ascigerous to non-ascigerous condition so frequently met in life-history work with the imperfect fungi.

VARIABILITY IN SPORE MEASUREMENT.

Since the beginning of mycology it has been customary to give spore measurements in specific description, probably originally with the idea of giving some information as to the approximate size of the plant concerned rather than to give exact descriptive limitations. With the advance of time, great importance has come to be attached to spore measurements—greater, perhaps, than is warranted—and many species are now founded upon divergence in this one character, and often upon slight divergence.

To ascertain the variability in spore measurement under constant conditions and its variability as occasioned by change in environment, studies with several species of fungi were undertaken.

The measurements were all made in water in which the spores had stood long enough to become fully turgid, taking only such spores as were completely ripe, as was shown by the fact that they were extruded from the pycnidium, ascus, or sporodochium, naturally, without assistance. An eye-piece micrometer was used and the units here employed are usually one division of the eye-piece scale,[1] which constituted in most cases as small a unit as could be used to advantage. Spore measurements involving half the division were recorded as with the next lower interval. To avoid any possibility of unconscious selection, the spore lying closest to contact with the end of the micrometer scale at the completion of a measurement was taken for the next measurement.

In the polygons each small square (one 256th of a square inch) represents one spore.

We wish to acknowledge our indebtedness to Dr. G. H. Shull, who has kindly read this portion of the manuscript, for calculating the constants; to Mr. B. B. Higgins, by whom most of the measurements were made and upon whose very accurate and painstaking work the value of the measurements depends.

ASCOCHYTA CHRYSANTHEMI STEVENS.

A. *Spores from the large pycnidium type* (see page 59).

Pycnidium No. 1. A large pycnidium produced in a colony which had very few pycnidia.

$M = 4.9645 \pm 0.0393$

$\sigma = .9787 \pm 0.0278$

C. V. $= 19.714 \pm 0.581$

$n = 284$

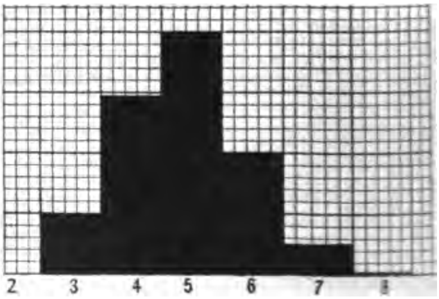


FIG. 16.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 1, large type. 3 should cover 20 squares instead of 25.

---

[1] Division equal 3.7 μ.

Pycnidium No. 2. Large type.

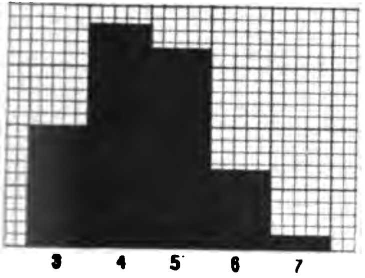


Fig. 17.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 2, large type.

$M = 4.4318 \pm 0.0398$
$\sigma = .9589 \pm 0.0281$
$C. V. = 21.638 \pm 0.650$
$n = 254$

Pycnidium No. 3. From a plate bearing one large colony. The whole colony was characteristically one of few pycnidia which were of large type and light color. The spores were obtained without any possibility of the pycnidium being torn, that is, they were normally ripe spores.

$M = 3.3848 \pm 0.0245$
$\sigma = .6714 \pm 0.0173$
$C. V. = 19.836 \pm 0.531$
$n = 343$

It is seen that these three separate pycnidia of the same type gave modes of 4.9645 ± 0.0393, 4.4318 ± 0.0398, and 3.3848 ± 0.0245; or, expressed in terms of the systematist, that in the three pycnidia the spores measured 11.1-29.6μ, mostly 18.5μ; 11.1-25.9μ, mostly 14.8μ; 7.4-22.2 μ, mostly 11.1 μ; showing that measurements from one pycnidium alone are not sufficient for reliable characterization.

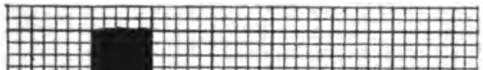


Fig. 18.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 3, large type.

B. *Spores from small pycnidium type* (Fig. 14).

Pycnidium No. 4. Small type.

M= 3.6011 ± 0.0363
σ= .7183 ± 0.0256
C. V.=19.947 ± 0.740
n=178

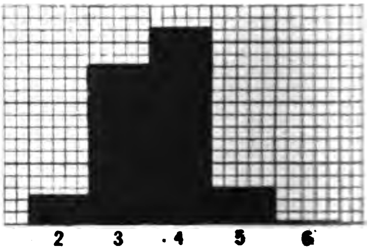


FIG. 19.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 4, small type.

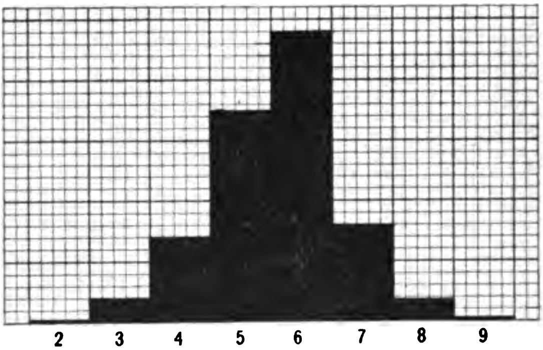


FIG. 20.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 5, small type.

Pycnidium No. 5.

Spores taken from small pycnidium colony shown in Fig. 14.

M= 5.5850 ± 0.0414
σ= 1.0737 ± 0.0293
C. V.=19.225 ± 0.543
n=306

Pycnidium No. 6. A very small pycnidial type.

M= 5.3629 ± 0.0544
σ= 1.2711 ± 0.0385
C. V.=23.702 ± 0.756
n=248

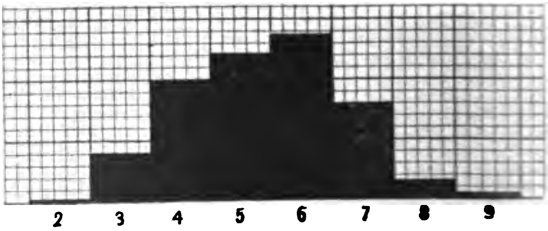


FIG. 21.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 6.

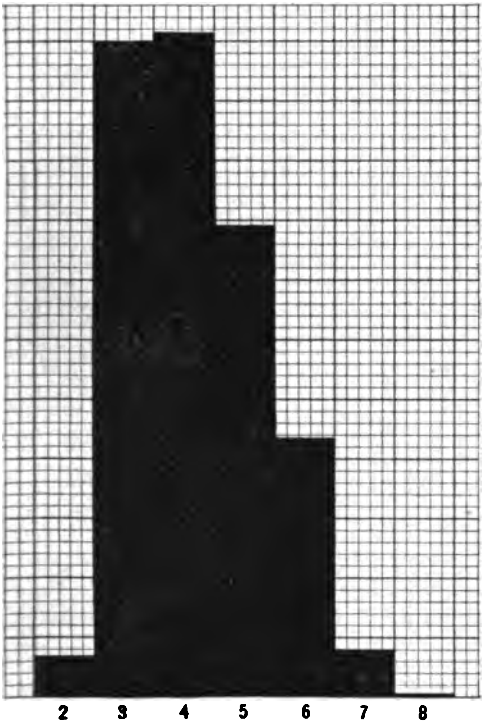


FIG. 22.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of large pycnidia.

Collecting the data from the large pycnidium type in one polygon, and similarly with the small pycnidium type, we have:

$$\begin{aligned} M &= 4.1935 \pm 0.0247 \\ \sigma &= 1.0902 \pm 0.0174 \\ C.\ V. &= 25.998 \pm 0.443 \\ n &= 889 \end{aligned}$$

$$\begin{aligned} M &= 5.0379 \pm 0.0335 \\ \sigma &= 1.3492 \pm 0.0237 \\ C.\ V. &= 26.781 \pm 0.503 \\ n &= 738 \end{aligned}$$

It is seen that there is a tendency throughout for the smaller pycnidia to produce larger spores than are produced by the large pycnidia.

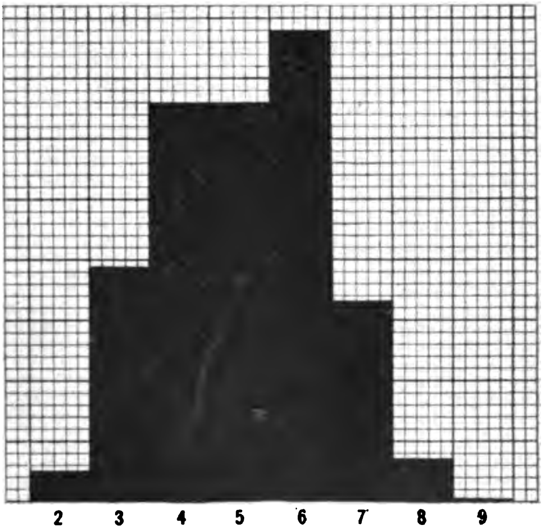


FIG. 23.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of small pycnidia.

C. *Measurements of spores from different media.*

Pure agar. The pycnidia on this plate were very scant, although they were normal in appearance and size.

$$
\begin{aligned}
M &= 2.6241 \pm 0.0313 \\
\sigma &= .5354 \pm 0.0221 \\
C.\ V. &= 20.402 \pm 0.878 \\
n &= 135
\end{aligned}
$$

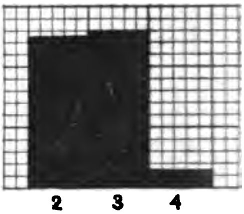


FIG. 24.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pure agar.

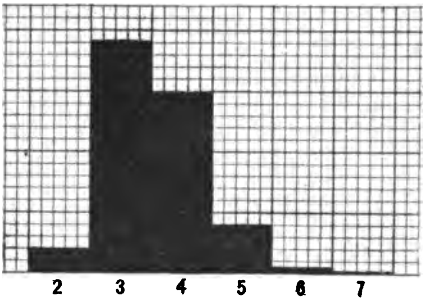


FIG. 25.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba + 0.25 per cent sodium asparaginate.

Cba+0.25 per cent sodium asparaginate.

$$
\begin{aligned}
M &= 3.5637 \pm 0.0358 \\
\sigma &= 0.7579 \pm 0.0253 \\
C.\ V. &= 21.267 \pm 0.725 \\
n &= 204
\end{aligned}
$$

$$
\begin{aligned}
M &= 5.4267 \pm 0.0356 \\
\sigma &= .7896 \pm 0.0251 \\
C.\ V. &= 14.551 \pm 0.459 \\
n &= 225
\end{aligned}
$$

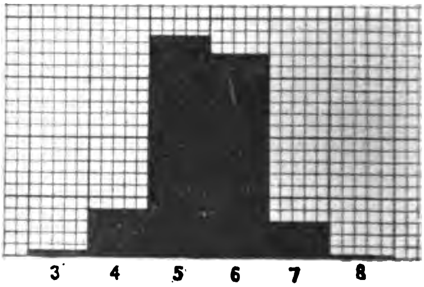


FIG. 26.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba+sodium asparaginate+starch.

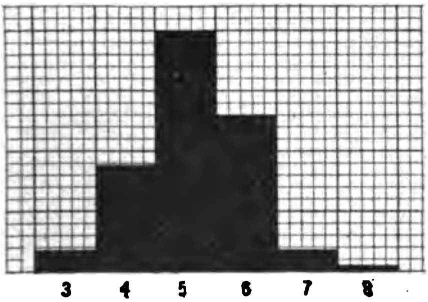


FIG. 27.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba+sodium asparaginate+glucose.

Cba + 1 per cent glucose. This was a remarkable colony with spores distinctly smoky or olivaceous.

M= 5.1422 ± 0.0408
σ= .9214 ± 0.0289
C. V.=17.919 ± 0.579
n=232

Plated thickly in 4 per cent pea agar.

M= 4.3246 ± 0.0392
σ= 1.0138 ± 0.0277
C. V.=23.442 ± 0.674
n=350

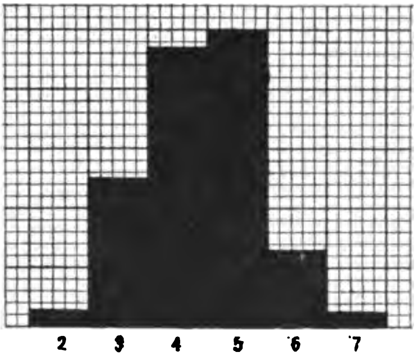


FIG. 28.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from 4 per cent pea agar.

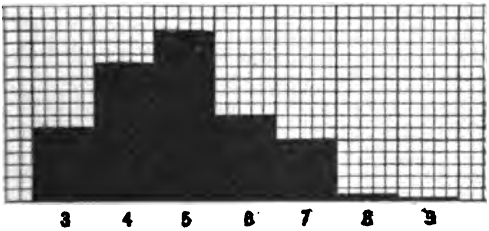


FIG. 29.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cowpea agar.

Cowpea agar.

M= 4.8657 ± 0.0545
σ= 1.1885 ± 0.0386
C. V.=24.427 ± 0.839
n=214

It is seen that on these different media the mode varies materially, being low on pure agar, higher on cba+sodium asparaginate, and still higher when glucose or starch is added. The mode is high also in natural media, such as pea agar and cowpea agar.

In the terms of the systematist, spores from pure agar measured 7.4-14.8 μ, mostly 11.1μ; those from cba+sodium asparaginate 7.4-25.9μ, mostly 12.9μ.

SEPTORIA LYCOPERSICI SPEG. OF TOMATO.

Grown on apple agar.

M=21.507 ± 0.190
σ= 4.686 ± 0.135
C. V.=21.787 ± 0.655
n=278

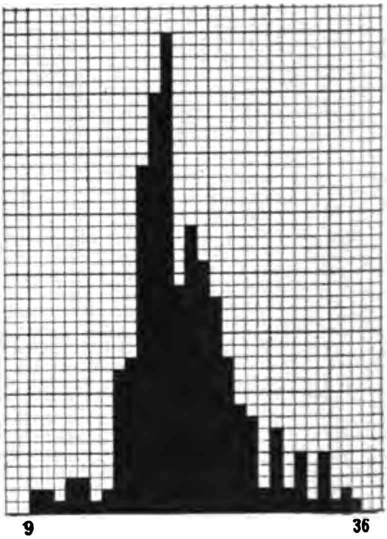


FIG. 30.—*Septoria Lycopersici* Speg. Polygon of spores on apple agar.

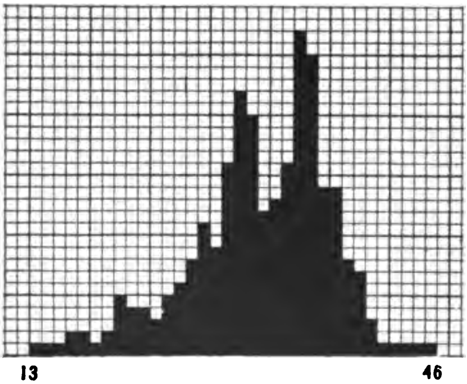


FIG. 31.—*Septoria Lycopersici* Speg. Polygon of spores on pure agar.

Grown on pure agar.

M=31.675 ± 0.242
σ= 5.879 ± 0.171
C. V.=18.560 ± 0.559
n=279

Although the number of spores measured in the two last instances is not large, the fact of a tendency to larger spores on the poorer medium, apple agar, is evident. The spores measured 33.6-133.2 μ, mostly 81.4 μ, those on pure agar 48.1-181.3 μ, mostly 133.2 μ.

Ascospores of Sclerotinia Libertiana Fuckel.

Spores were discharged spontaneously from the disk upon the cover glass, the disk being of middle age.

$$M=4.0880\pm0.0166$$
$$\sigma=0.2930\pm0.0117$$
$$C.\ V.=7.168\ \pm0.290$$
$$n=142$$

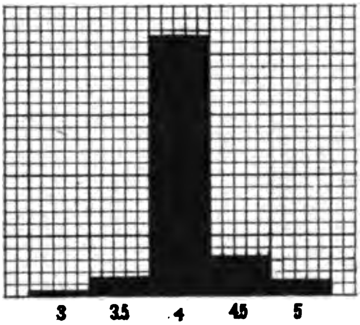


Fig. 32.—*Sclerotinia Libertiana* Fckl. Polygon of ascospores from middle-aged disk.

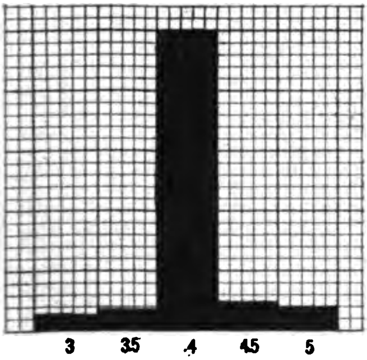


Fig. 33.—*Sclerotinia Libertiana* Fckl. Polygon of spores from young disk.

Spores were secured as in the last instance, but from very young disks.

$$M=4.0393\pm0.0214$$
$$\sigma=0.3743\pm0.0151$$
$$C.\ V.=9.267\ \pm0.380$$
$$n=165$$

No material difference in the size of the spores here appeared with the change in age of the disks.

DIPLODIA MACROSPORA EARLE.

Spores of this species, isolated from corn, were grown upon pea agar.

M=24.362 ± 0.176
σ= 3.179 ± 0.124
C. V.=13.050 ± 0.519
n=149

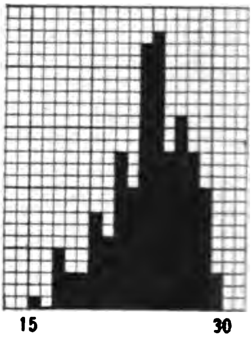


FIG. 34.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing length.

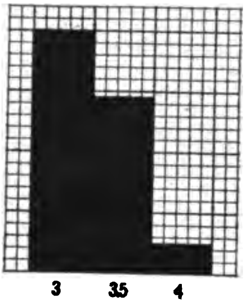


FIG. 35.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing thickness.

M=3.2595 ± 0.0136
σ= .2727 ± 0.0096
C. V.=8.367 ± 0.297
n=183

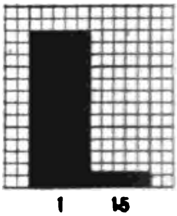


FIG. 36.—*Volutella fructi* S. and H. Polygon of spores showing width.

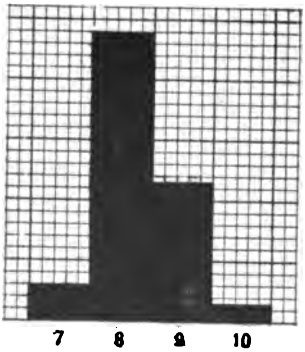


FIG. 37.—*Volutella fructi* S. and H. Polygon of spores showing length.

VOLUTELLA FRUCTI S. AND H.

M=8.27 ± 0.0276
σ= .5778 ± 0.0195
C. V.=6.986 ± 0.237
n=200

The last five polygons are without particular significance and serve only to show the variation encountered in these forms.

General Considerations.

The bearing of these facts upon mycological taxonomy is apparent. If a fungus can be easily changed as regards its essential descriptive characters by a change in substratum, density of infection or other environmental factor, these characters are worthless for descriptive purposes, unless the conditions under which they develop be accurately known.

There are two fundamental requisites of benefits from description: (1) to enable recognition of a particular form; (2) to aid in classification.

The first of these is necessary preliminary to the second, and it is with mere recognition that we have in many instances yet to deal in mycology, particularly among the group *Fungi imperfecti* with its enormous genera, such as *Septoria* and *Phyllosticta* and *Cercospora* with their thousands of so-called species. While life-history work and infection experiments will do much, accurate recognition of the form in hand is a necessary preliminary even to this.

To reach any satisfactory basis, many fungi must be studied in culture much after the fashion that bacteria are now studied.

CARNATION ALTERNARIOSE.[1]

By F. L. Stevens and J. G. Hall.

To a leaf and stem disease of the cultivated carnation, *Dianthus Caryophyllus* L., our attention was called by local florists as causing serious damage. The disease, upon examination, proved to be one hitherto undescribed, and a laboratory study of it was undertaken.[2]

SYMPTOMS.

The disease manifests itself as spots, mostly upon the leaves, sometimes upon the stems, especially at the nodes. These spots are strikingly characteristic, of ashen whiteness, with the center occupied by an often scanty, though sometimes profuse black fungous growth. The diseased spot is dry, somewhat shrunken, thinner than healthy portions of the leaf, approximately circular, though often somewhat elongated in the direction of the longitudinal axis of the leaf. (Fig. 38.) When occurring at the node, the disease usually involves the bases of both of the leaves, as well as the stem between them. (Fig. 38, 2.) As these nodal spots age the disease penetrates through the stem, killing its tissue, which shrinks somewhat and becomes soft and disintegrated, resulting in death of the more distal portions of the plant.

VARIETY OF CARNATIONS AFFECTED.

A striking feature of this disease is its tendency to infect to a large degree one variety of plant, the Mrs. Thomas W. Lawson, to the exemption of others. In all cases which have come to our notice it has been this variety solely which was diseased; moreover, the only records that we find of the disease imply the same susceptibility.[3]

CAUSAL FUNGUS.

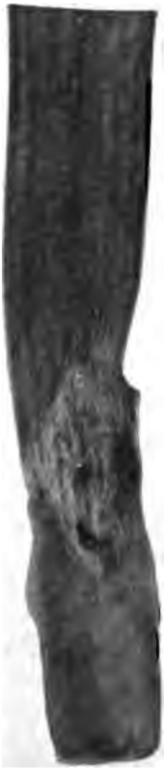
Throughout the diseased tissue of all spots occurs in great abundance a characteristic, dark, branching, septate mycelium (Fig. 40, 3). The surfaces of diseased spots in periods later than their earliest youth present an abundance of black cespitose hyphæ arising from the stomata (Fig. 40, 4). Spores of the Alternaria type are found in abundance, Figs. 40 (5) and 40 (6), both *in situ* upon these hyphæ, and strewn over the surface of the diseased spots between the hyphal bases. The character and arrangement of the hyphæ is shown in Figs. 40 (7) and 40 (8). This fungus was constantly associated with the disease, and no other fungus was found. The presumptive evidence was therefore very strong that this fungus was the cause of the disease. In view of the often saprophytic habit of Alternaria, conclusions on this point would not be valid without evidence from inoculations.

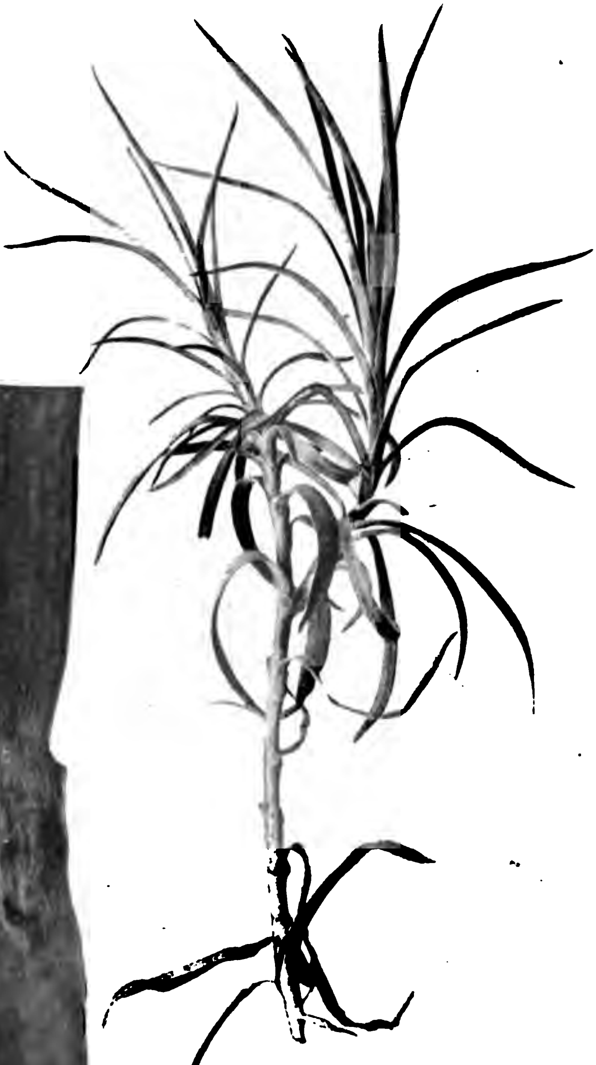
---

[1] Printed in the Botanical Gazette, 47, No. 5, May, 1909.

[2] Through the kindness of Dr. Orton, U. S. Department of Agriculture, we learn that a *Macrosporium* disease of carnation was reported from Strassburg, Pa., in 1906, and one attributed to *Alternaria* from Connecticut by Clinton in the same year.

[3] Orton, Year-book U. S. Dept. Agr., 1905, p. 611.





1 2

Fig. 38.—(1) Single leaf showing diseased spot near base. (2) Diseased plant showing removal of lower leaves by the gardener in his efforts to stop the progress of the disease.

INOCULATIONS.

The fungus was easily isolated by direct transfer of spores from the diseased spots to carnation leaf agar plates.

On October 27 numerous inoculations were made upon two plants under bell jars, using small pieces of agar, bearing spores and mycelium. One of the plants was left uninjured and the inoculum was placed in the axils of the leaves; in the majority of these cases the inoculations resulted in infection. The other plant was injured by the prick of a needle at the point of inoculation. In these cases about two-thirds of the inoculations were successful. Inoculations with spore suspension were also made upon five branches each, of two other plants, and each was covered by a large test tube plugged around the stem with cotton to preserve a humid atmosphere. As in the former cases, the inoculations on one plant were at injured points and those on the other plant were at uninjured points. The results from these spore inoculations were the same as in the cases of inoculations with agar blocks. When these inoculations were made, others were made upon six other plants

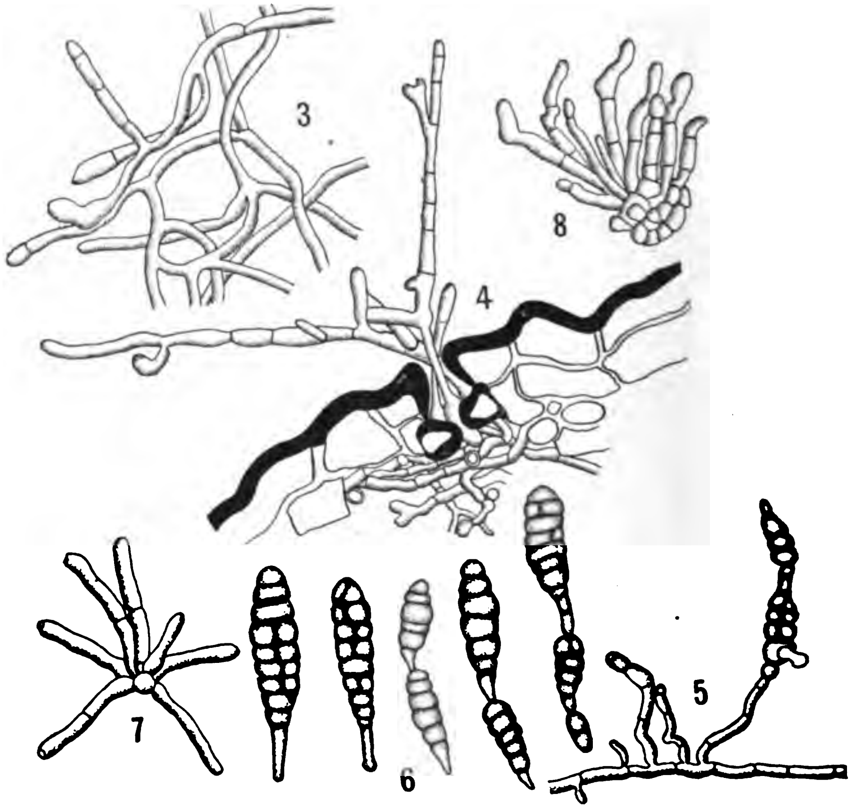


FIG. 40.—(3) Mycelium showing branching and septation. (4) Showing mycelium below stoma and hyphæ emerging through the stoma. (5) Showing catenulate spores as borne upon hyphæ. (6) Spores showing shape, septation and catenulation. (7) A young cluster of hyphæ. (8) An older cluster of hyphæ.

from the same spore suspension, but the plants were not covered or injured in any way. Following these last inoculations no signs of the disease were seen. It seems from these experiments that the injured plant is readily susceptible to infection, as is also the uninjured plant if kept in humid condition, but that the uninjured plant in a relatively dry atmosphere is difficult or impossible of infection. In case of successful inoculation the diseased spots were well developed at the end of a week. The removal of the protecting bell jar from plants already infected resulted, usually, in cessation of development of the spot. These facts agree well with the field observation that the most damaging infection occurs at the leaf axils, points well adapted to collect and hold water, thus providing conditions for optimum development of the fungus.

CULTURE CHARACTERS.

The fungus was grown upon many different media. Its characters upon these media have been noted elsewhere.[3] The most important culture characters may be summarized as follows:

Upon media poor in available carbohydrates the mycelium was nearly hyaline and the hyphæ and spores pale; upon media rich in carbohydrates mycelium, hyphæ and spore were very dark. Upon the natural medium the spores were more regular and uniform in shape and were much larger than upon artificial media.

SPECIES OF THE FUNGUS.

Of the Alternarias there seems to be only one, *A. longispora* McAlph, growing upon members of the pink family (*Caryophyllaceæ*), (Sacc. Syll. Fung., 18:638), and the description of this does not agree with ours in size, shape, or septation of its spores.

Therefore, unless an attempt be made to identify this form with some one of the seven or more species of Macrosporium infecting the pink family—a procedure which would be unjustifiable without resort to cross-culture inoculations and extensive study in artificial media—this form had best be designated as a distinct species, for which we propose the following name and description:

Alternaria Dianthi n. sp.

Hyphæ cespitose from stomata, amphigenous, dark brown, 1-4 septate, ascending, 1-25 from each stoma; conidia 26-123 x 10-20 μ catenulate, clavate, tapering to pedicul, base obtuse, dark brown, transverse septa 5-9, longitudinal septa 0-5.

Spot ashen white definite, subcircular.

On artificial media poor in carbohydrates color of mycelium and spores lighter, smaller and with fewer septa.

Habitat: Living leaves and stems of *Dianthus Carophyllus*, Raleigh, N. C.

---

[3] Stevens and Hall, Variation in Fungi Due to Environment, Bot. Gaz. 48, July, 1909.

HYPOCHNOSE OF POMACEOUS FRUITS.[1]

BY F. L. STEVENS AND J. G. HALL.

A disease which from its most prominent symptoms may popularly well be called the *leaf blight* and which may technically be designated as *Hypochnose*, has been under observation and study by the authors several years, as affecting the apple, pear, and quince. During this time it has been frequently referred to the Experiment Station for diagnosis and treatment, and it seems to be one of the worst diseases occurring on neglected trees in the humid portions of the State.

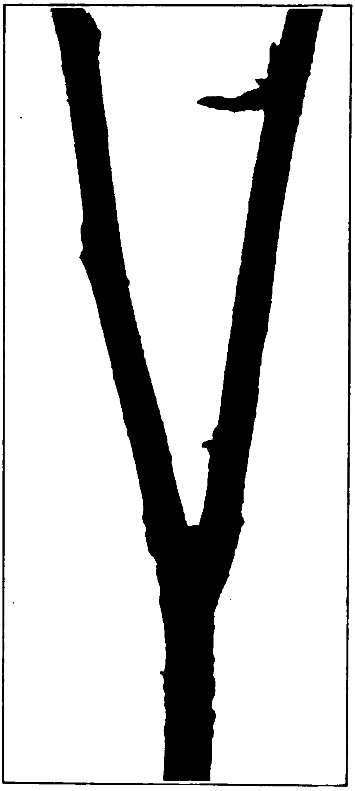


FIG. 41.—Sclerotia and rhizomorphic mycelium upon apple twigs; natural size.

SYMPTOMS.

Viewed from some distance, trees in early stages of *Hypochnose* appear much as do trees affected with the ordinary fire blight (*Bacillose*) caused by *Bacillus amylovorus* (Burrill) De Toni, that is, the leaves on numerous twigs throughout the trees are dead. Differing from *Bacillose*, however, the leaves instead of standing erect, usually droop, hanging down in dense, matted masses. The affection, too, is limited to the leaves, the twigs themselves not dying as in the case of *Bacillose*. The resemblance is very striking, and to the casual observer *Hypochnose* would doubtless pass for the widespread, well-known "fire blight."

---

[1] Printed in Annales Mycologici, Vol. 7, No. 1, 1909.

In later stages of the disease most of the affected leaves fall away and the similarity to *Bacillose* disappears, the tree now attracting attention chiefly by its scant equipment of leaves. Closer inspection of the twigs with the affected leaves shows each of them to bear two characteristic structures:

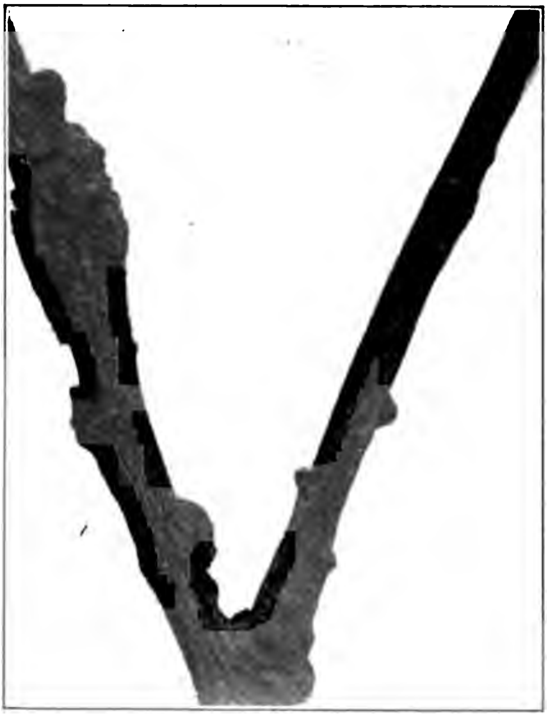


Fig. 42.—Sclerotia on apple twigs, enlarged.

1. Roundish or oblong sclerotia, usually 3 or 4 mm. in diameter, which are clearly shown on the left-hand branch in Fig. 41, and somewhat enlarged in Fig. 42.

2. Mycelial ribbons, rhizomorphic structures extending lengthwise of the twigs and petioles. (Fig. 43.)

The sclerotia originate as white masses of interwoven mycelium, which when mature become rich chestnut brown in color. They are formed in great abundance upon the twigs of the current year, especially upon the lower, shaded, damp side, but very sparingly or not at all upon the petioles or leaves. On two-year-old twigs the sclerotia are darker in color, shriveled and sometimes cracked, and it is doubtful if they live longer than through the summer following their origin. Upon badly affected trees it is possible to find sclerotia upon older twigs, two, three, four, or five years old, the size of the sclerotia being diminished by waste, shrinking, and weathering, with the age of the wood upon which they rest. Sclerotia are sometimes found upon fruit, though much less frequently than upon twigs.

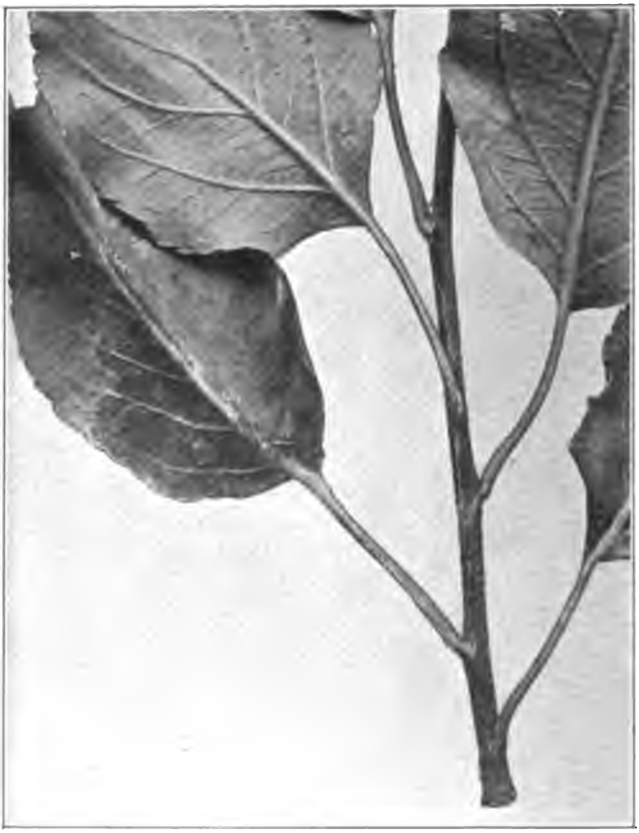


FIG. 43.—Rhizomorphic mycelium upon apple twigs and petioles; weft of floccose mycelium on interior surface of leaf.

The mycelial rhizomorphic structures when young are white, but as they age they rapidly assume a characteristic glistening brown appearance. They extend in a general longitudinal direction, and usually remain unbranched between the nodes, though they sometimes branch and anastomose, forming a small plexus. Occasionally branches diverge to courses leading around the twig. At the base of each small twig the ribbon usually branches, a portion of it passing onto the smaller twig.

Branches of these mycelial ribbons also follow up the petioles and the main veins of the leaves, eventually spreading out, separating into single mycelial threads and becoming lost to the naked eye. The mycelial ribbons on the older wood die and often weather away, though they adhere with considerable persistence.

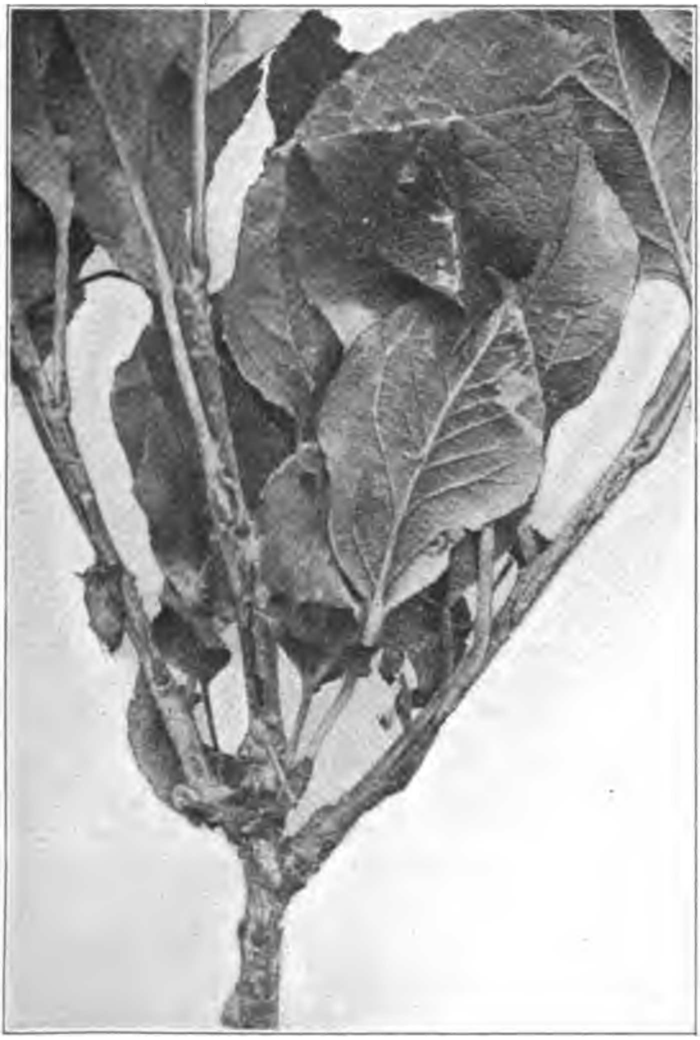


FIG. 44.—Apple twig showing characteristic matting of dead leaves held together by dense growth of mycelium; twigs and leaves densely covered by mycelium and sclerotia.

Upon the under surface of affected leaves may be found usually a more or less dense reticulum of mycelial threads. In some instances this weft consists of a dense mat of threads, white or fuscous according to their age (Fig. 43, lower left-hand leaf), in other cases the network may be so sparse as to be imperceptible to the naked eye.

In all cases there is organic connection between this network on the leaf and the mycelial ribbons traversing the petiole. These ribbons are seen under the microscope to fray out and become dissipated over the under leaf surface.

The organic connection between the reticulum on the leaves, the mycelial rhizomorphic strands, and the sclerotia is established clearly and beyond doubt.

In some cases, comparatively rare, the weft on the lower surface of the leaf takes on more even texture, different from the tangled heaps more often found. In this condition the weft can be stripped from the leaf like a false epidermis. This is the sporogenous part of the fungus.

The twigs bearing the fungus do not die from its presence. They seem to be injured only indirectly through the effect of the fungus upon the leaves.

Leaves bearing the fungus turn brown and die. Since they droop in dying, they thus often come in contact with other leaves and the fungus is afforded a ready means of migration to the new victim, which in turn rapidly succumbs. If humid conditions prevail, the fungus grows with great rapidity and vigor between the matted masses of leaves, thus resulting in fastening the dead leaves somewhat firmly together and furnishing one of the distinguishing characteristics of the disease. (Fig. 44.)

FUNGUS.

The mycelial ribbons, which may be termed the *migratory mycelium*, to distinguish it from the vegetative and fructifying mycelium, consist of more or less parallel mycelial threads very uniform in diameter, about 5.8 μ, comparatively thick, walled and rigid, of characteristic glistening, smooth surface, white when young, tawny or buff when old, and nearly or quite devoid of protoplasmic contents. These threads are septate at intervals of about 40-120 μ. and branch rather infrequently. The branches originate usually at right angles to this mother strand, but almost immediately bend to assume a direction parallel to the main ribbon. No clamp connections were seen.

A section of the sclerotia reveals them as compactly woven masses of swollen irregular hyphæ. They are entirely devoid of any special epidermal structure, false epidermis, or rind, the peripheral structure being identical with that of the interior.

The sporogenous reticulum is of very close, irregular mesh of hyphæ of varying thickness, readily distinguished from the migratory mycelium, a single thread of which is occasionally seen across the field, by its thinner wall, greater irregularity of shape and size, and by its richness of protoplasmic content. Arising from the hyphæ of this reticulum are numerous thickened swollen branches which prove to be the basidia, bearing four slender sterigmata which bear the four spores. (Fig. 45.)

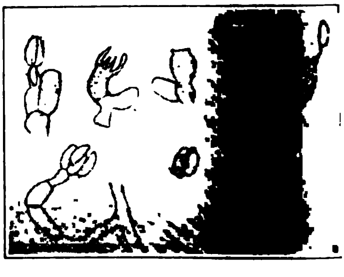


FIG. 45.—Basidia, sterigmata and spores.

The spores are oblong, slightly flattened on the side adjacent to the companion spore and taper slightly at each end. They are very uniform in size.

4.7 - 5.8 x 10.5 - 11.6 μ. Of thirty-eight spores measured, thirty were of the larger dimension given and eight of the smaller dimension.

When stored in humid atmosphere, as in a culture dish, for a day or so, the fungus grows luxuriantly, producing great quantities of cotton-like mycelium. (Fig. 44.) The fungus was seen to spread 1 cm. in every direction from the point of contact in two and one-half days, when leaves bearing the fungus in this vigorous vegetative condition were placed in contact with healthy leaves in the moist chamber. Specimens wrapped to mail, when wet from rain, produced voluminous growth in forty-eight hours, many leaves becoming matted together, others becoming completely covered with the cotton-like mycelium and fringed on the edge with a border of mycelium reaching out for more victims.

The development of the fungus in early spring has not been studied, but it is clear that the sclerotia are hibernating structures and that in spring they serve as the initial points for new invasion. The spread of the fungus from point to point is chiefly by means of the rhizomorphic structures, which serve the purpose so admirably that by midsummer the uppermost buds are reached and already overlaid by sclerotia ready to carry on the invasion again another season. The work of the sclerotia is so completely done that rarely, if ever, does the parasite allow the escape of any of the branches originating from a twig upon which the fungus has established itself. Unless saved by outside aid, to be once infected is to be always infected.

A beautiful adaptation is noted in that the formation of sclerotia is abandoned on leaves where they would be of but minor importance, perhaps of no use at all, and is carried to a maximum upon twigs, particularly the most distal ends of the twigs, where they are of maximum utility in the perpetuation of the species.

The perfection of vegetative methods of reproduction has lessened the value or necessity of spore formation, a fact which perhaps explains the comparative rarity of fructification in this fungus.

THE FUNGUS IN NORTH AMERICA.

While the spore-bearing structures of this fungus were not seen, and consequently its classification was not known in America until 1907,[1] its sclerotia and rhizomorphic structures have several times come to the attention of mycologists in the United States. Thus Atkinson writes us that he believes he had the same thing sent him when he was connected with the Alabama Station.

Burt writes in private letter that the sclerotia were known to him, but he did not receive the fructification. He also states that specimens of the sclerotial stage have been referred to him on living twigs of apple, and on pear twigs.

Farlow says that sterile parts of the fungus have several times been referred to him. The sterile parts of this fungus and the destructive effects of it were noted by Quaintance with photographs and with the statement[2] that the fungus is known in Florida and Georgia, and that in one case it constituted for several years the most destructive fungus in the orchard.

---

[1] STEVENS, Two Interesting Apple Fungi, Science, n. s. 27, p. 724.
[2] Ga. Sta., 13th Rpt., 1901, p. 359.

Earle states in private communication that the fungus was sent to the Alabama Station several times from Florida and Georgia while he was connected with it.

What was probably the same fungus was also mentioned by Sheldon as occurring upon apple, pear, and plum twigs, and by hearsay upon currant, gooseberry, and cherry in West Virginia.[3]

Collections in North Carolina have been made on the apple at Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola, Mount Airy, Spruce Pine, Rutherfordton, Chimney Rock; on the pear at Sylva, and on the quince at Horseshoe.

Collections of spore-bearing material were made at Mount Airy, Spruce Pine, and near Rutherfordton.

IDENTITY OF THE FUNGUS.

This fungus in all of its remarkable characters agrees with the description of *Hypochnus ochroleucus* Noack,[4] published by Noack as *Hypochnopsis*, a fungus which was found by Noack in the State of Minas Geraes, Brazil, on apple and quince trees, and which was supposed to be the cause of a diseased condition of the leaves. Noack says in part that the apple trees and quinces attacked by this fungus were brought to his attention by the dryness of many leaves. "Examined more closely, one sees fine, shining strands, white or ochre color, on the branches, often in spiral or elongated spiral lines. They approach the pedicels of the leaves, follow up the same, spread over and cover the lower side of the leaves with a very fine net of hyphæ. A few of these hyaline hyphæ end in corrolloid branches fastened strongly to the skin of the leaf and serve, doubtless, for the purpose of attaching the fungus to it. * * * The attacked leaves wilt and dry altogether, but they can remain on the trees a long time, adhering together in a confused mass, attached to the branches mainly by the tenacious threads of the mycelium. * * * Unfortunately, we are lacking its fructification, and for that reason its classification is doubtful. But we can find a very similar fungus belonging to the family of *Hypochnaceae* in the forest around Campinas, and therefore we call it provisionally our *Unknown Hypochnopsis*."

While it has been impossible to find specimens of Noack's fungus in any of the Brazilian or European herbaria, there seems to be no doubt of its identity with the form under discussion.

DISTRIBUTION.

This disease prevails generally throughout the mountain section of North Carolina; and that it is not limited to the mountains is shown by the fact that specimens have been sent to us from the coastal plain region with complaints of damage. (Fig. 46.) From the observations of Atkinson, Earle, Quaintance, and Sheldon, its presence is known in the mountains of West Virginia and in Alabama, while the observations of Farlow and Burt indicate its much more widespread existence.

---

[3] W. Va. Sta. Rpt., 1905–06, p. 31.

[4] Saccardo, Sylloge Fungorum, 16, p. 197.

[5] Boletim do Instituto Agronomico do estado de Sao Paulo Em Campinas. 9, 1898. Marco Numero 1, Sao Paulo, Brazil.

Our own observation, agreeing with those of Noack in Brazil, show the disease to occur with much greater destructiveness in humid localities, such as the mountain valleys where the dew is excessive and morning fogs prevail, and it seems probable that this disease is of wide distribution where these conditions obtain.

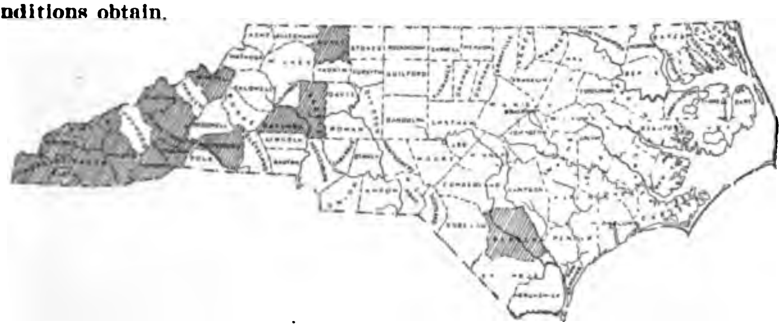


FIG. 46.—Map of North Carolina; shaded counties are those in which disease occurs.

PROPHYLAXIS.

The fungus, wintering in a purely superficial manner upon the twigs and depending to but a slight degree upon spores, will probably give way to thorough spring sprayings. The fact that the disease has not been noted upon sprayed orchards indicates the efficiency of such treatment.

PARASITISM OF HYPOCHNUS AND CORTICIUM.

These genera, which are difficult to separate and which by many are considered as identical, are in the main saprophytes, yet several cases of parasitism have been attributed to them. Among the parasitic forms Frank[6] in 1895 recognized only two as belonging to the genus *Hypochnus*, viz., *H. Solani* P. & D., noted on potatoes as early as 1891,[7] and *H. cucumeris* Frank,[8] which was noted as the cause of a cucumber disease in 1883 and later on lupine and clover. *H. filamentosus* Pat. has since been described as growing upon live leaves of *Caryophyllaceæ* and *Amaryllidaceæ* in Quito, and Eustace has recently discussed a species of *Hypochnus* as causing a decay of stored apples.[9]

H. Gardeniæ. Zimm., described by Zimmerman,[10] closely resembles the species in hand in the formation of ribbon-like strands on the twigs, which then extend to the lower sides of the leaves and develop a sporogenous layer; also in the structure of its fruiting portion.

H. Hellebori Rostr. is noted as a parasite upon *Helleborus niger* by Rostrup.[11]

H. fuciformis (Berk.) McAlp. grows parasitically upon Australian grasses in very destructive form.[12]

In the genus *Corticium* as parasites we find the following:

C. confluens Fries, noted by Jaczewski as a faculative parasite preying upon *Caragana.*[13]

---

[6] Die Krankheiten der Pflanzen, 2, p. 219.
[7] Soc. Myc. Fr. 8, p. 221.
[8] Hedwigia 18, p. 127.
[9] N. Y. Sta. Bul. 235.
[10] Centbl. Bakt. II, 7, p. 102.
[11] Ztschr. Pflanzenkrank, 9, p. 47.
[12] Ann. Mycol., 4, p. 341. McAlpine, A New Hymenomycete.
[13] Ztschr. Pflanzenkrank, 10, p. 341.

C. vagum B. & C. var. *solani*, which has been identified by Rolfe as the fruiting form of *Rhizoctonia.*[14]

C. javanicum (P. Henn.) Sacc. & Syd. on *Coffea*, *Thea*, *Bixa*, described as the cause of disease by Zimmerman.[15]

Associated with this fungus are sclerotia, probably genetically connected with it. Disease caused by the fungus upon a large number of other plants is mentioned by Zehntner.[16]

C. dendriticum P. Henn. is noted by Hennings[18] as a parasite on orange stems.

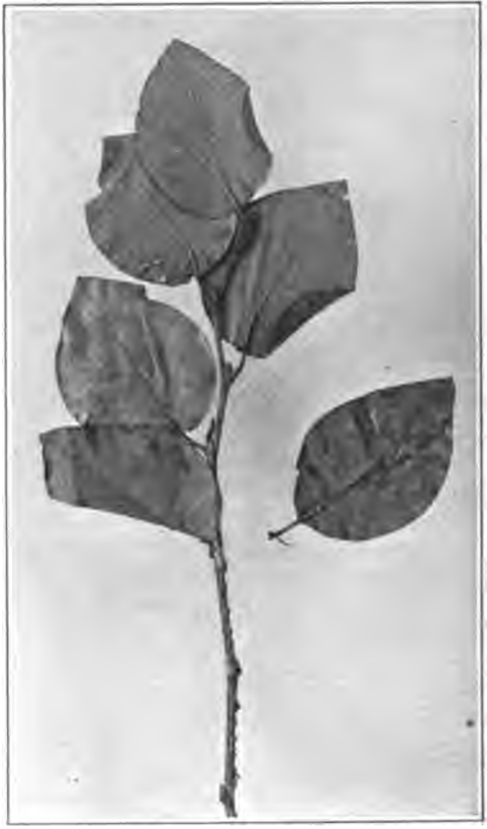


FIG. 47.—Quince branch and single leaf, showing sclerotia and mycelial masses.

ADDENDUM.

Since the preparation of the above article this fungus has come to our attention upon two new hosts, and collections on old hosts have been made in several new localities, as is indicated on next page.

---

[14] Col. Sta. Bul. 91.
[15] Centbl. Bakt. II, 7, p. 102.
[17] Ztschr. Pflanzenkrank, 18, p. 45.
[18] Centbl. Bakt. II, 9, p. 939.

On Apple.

Robbinsville	August 6, 1909	F. L. Stevens.
Murphy	August 9, 1909	F. L. Stevens.
Hayesville	August 10, 1909	F. L. Stevens.
Eulalie	August 14, 1909	F. L. Stevens.
Leicester	July 17, 1909	B. B. Higgins.

On Quince. (Fig. 47.)

Eulalie	August 14, 1909	F. L. Stevens.

On Snowball (Vibernum).

Eulalie	August 14, 1909	F. L. Stevens.

On Lilac (Syringa vulgaris).

Eulalie	August 14, 1909	F. L. Stevens.

In many sections of Western North Carolina the fungus was so prevalent as to be found on nearly every tree seen, and whenever present the disease was always of extremely destructive character, resulting early in complete defoliation.

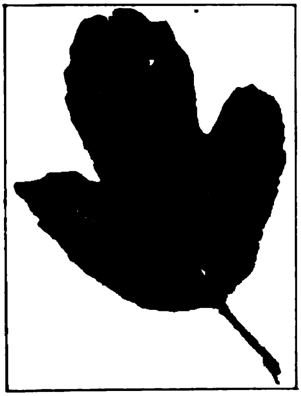


FIG. 48.—Leaf of Snowball showing white masses of mycelium.

The fungus on the Snowball (*Vibernum*):

Only one collection was made on this host (though what was supposed to be the same was glimpsed on other occasions), and then in a valley where the fungus grows with especial luxuriance upon its more usual hosts. The disease caused upon this host agrees in every particular with that upon the apple, except that as the leaf collapses under the attack of the fungus the mycelium accumulates in much more dense masses upon the under surface of the leaf. (Fig. 48.) This difference in habit may be due to the thinner texture of the leaf which allows it to fall into folds, thus producing regions of especial moisture and forming more vigorous growth of mycelium.

Fungus on Lilac (*Syringa vulgaris*):

Only one collection was made upon this host, and this in the same yard where the fungus was found upon apple, quince, and snowball. The characters of disease produced were almost identical with those upon the apple. No such development of loose mycelium appeared as upon the snowball, probably owing to the stiffness of the leaf.

NEW FIG ANTHRACNOSE[1] (COLLETOTRICHOSE).

BY F. L. STEVENS AND J. G. HALL.

A fig disease, the chief symptoms consisting of rotting and premature fall of the fruit, has come to our attention from the eastern part of North Carolina. The disease begins before the fruit commences to ripen, as small specks of rot on the fruit surface. Such rotten specks are usually very numerous, from five to thirty-five or more on each fig. The spots are soft, watery in appearance and definitely bordered. At their centers they are brownish and slightly sunken. The spots enlarge rapidly and very soon the central region of each is occupied by numerous small, moist, pinkish to salmon colored pustules, each less than a millimeter in diameter.

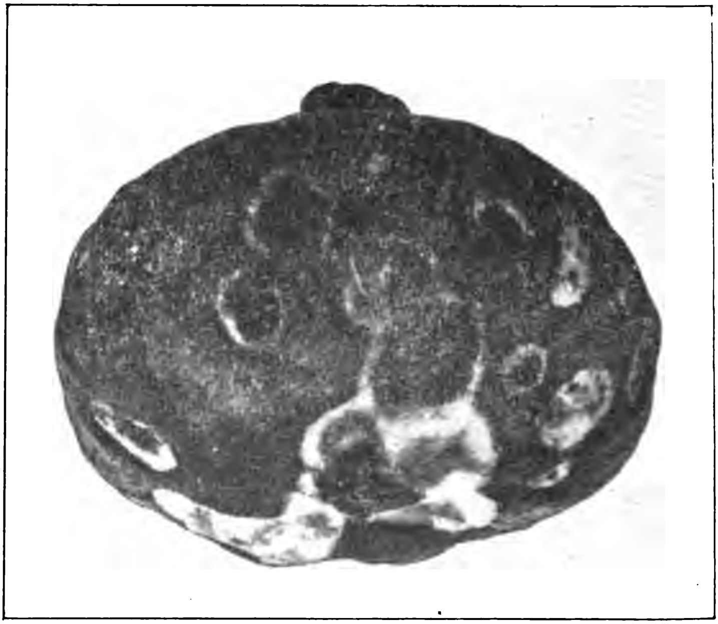


FIG. 49.—A single fig somewhat enlarged, showing white floccose mycelium around and over the spots.

The affected fig rapidly assumes a rotten appearance, loses its firmness, becomes watery, shrivels, and is soon almost entirely covered with the spore-bearing pustules. If under humid conditions, the spots become bordered and covered with a more or less dense growth of aërial, floccose, white hyphæ, which are sometimes so abundant as to produce a dense mat either over or surrounding the spot. This condition is shown in Fig. 49 somewhat enlarged.

---

[1] Presented at the December Meeting, 1908, of the A. A. A. S. Published in part in Zeitschrift f. Pflanzenkrankheiten 19, p. 65.

In later stages of decay the fig is usually invaded by a large number of saprophytic fungi, usually predominated by dark green or black.

The fruit usually falls early in the decay. The disease prevails to such an extent that an affected bush may fail each year to mature its fruit, though setting fruit in abundance. The leaves of the affected bushes are also often diseased, turning brown, shriveling at the edges, and dying. The rot resembles that of the apple (*Glomerellose*) and the spots in a general way resemble the disease spots of the cotton anthracnose (*Colletotrichose*) or that of the bean or watermelon.

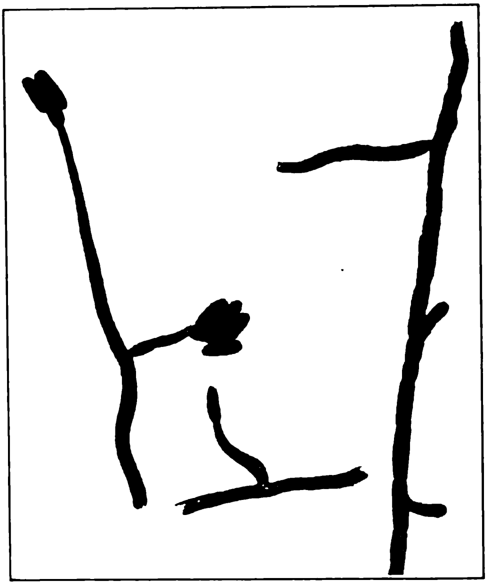


FIG. 50.—Showing mycelium, septation, branching and spores formation.

CAUSAL FUNGUS.

The diseased spots upon the fruit are always occupied by a species of *Colletotrichum*, which from the abundance of its spores seen *en masse* gives the pinkish color to the center of the disease spots.

The mycelium is slender (1.5 to 6 mu. in diameter), hyaline, much branched and sparingly septate. The branches in artificial culture arise at almost right angles from the parent branch (Fig. 50). The characteristic, greenish black appressoria of the anthracnoses are found.

The small, numerous hemispherical acervuli are brown to black until that color is obscured by the pinkish spores.

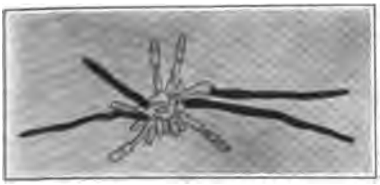


FIG. 51.—Portion of an acervulus showing conidia, conidiophores and setae.

The setae (Fig. 51), which may number from one to twelve, or which in many instances are entirely absent, are long, irregular, slender, tapering toward an acute point. They are dark colored throughout, rigid, septate.

The spores are regular, oblong, continuous with obtuse ends, borne upon slender hyaline conidiophores. The spores germinate very readily in almost any medium, sending out from one to three germination tubes each.

The fungus was very readily isolated by planting a suspension of spores from figs, as they came into the laboratory, in 4 per cent pea agar. These cultures produced great quantities of acervuli, from which, by replating, characteristic pure cultures were obtained. These were used for inoculations in both laboratory and field.

INOCULATIONS.

In the laboratory two methods of inoculation were followed: 1. Spores were rubbed upon the surface of the fruit. 2. The fruit was pricked with a sterile needle and the spores introduced into the injured spot. In both cases the spots characteristic of the disease were produced a day or two later, the fruit being kept in a culture chamber.

In the field a suspension of spores in water was sprayed upon a bush in fruit. Fifteen or twenty days afterward no indication of infection was apparent, but specimens showing no lesions when placed in sterile culture dishes in the laboratory, developed Colletotrichose after a few days in great abundance. Eight figs, placed in culture dishes, autoclaved, then inoculated, all showed the mycelium characteristic of the disease at and around the point of inoculation, the mycelium being much more abundant upon these sterilized figs than upon those not sterilized. In due time the salmon-colored spores of the disease appeared in numerous pustules on both sterilized and unsterilized fruits.

Further field inoculations made with an enclosed, moist atmosphere, September 26, 1908, showed rotten spots on October 1, although no fungus was visible. The fruit, all of which had fallen from the bush, was placed in sterile culture dishes in the laboratory, and at the end of three days all specimens showed the characteristic disease, and at the end of a week great masses of spores were visible.

It is clear from the inoculation experiments that this fungus will grow upon the fig, sterile or in natural condition, if in a humid atmosphere, but that it does not grow well upon raw figs in a dry atmosphere.

These results are in accord with our observations upon the distribution of the disease, which has been noted as yet only in exceedingly humid localities, as on our seaboard.

IDENTITY OF THE FUNGUS.

Upon the genus *Ficus* we find recorded four species of *Colletotrichum* and four species of *Gloeosporium*, which are as follows, with the host plants indicated:

1. *Colletotrichum elasticae* F. Tassi, in leaves of *Fiscus elastica* Italy.
2. *Colletotrichum elasticae* Zimm., in leaves *F. elastica*. Koorders says this is identical with *C. elasticae* F. Tassi.[2]
3. *Colletotrichum Fici-Elasticae* Zimm., in leaves *F. elastica* Java.

---

[2] Botanische Untersuchungenuber einige in Java vorkommende Pilze, besonders uber Blatter bewohnende, parasitisch aui tretende arten (Verh. Von. Akad. von Wetensch te Amsterdam Tweede Sect. Dert. XIII 4, p. 264), also (Notizblatt d. Konig Bot. Gart. u. Mus. zu. Berlin-Dahlem, No. 40, Bd. IV, 1907).

4. *Colletotrichum Fiscus*[3] Koord.

5. *Gloesporium intermedium* Sacc. var. *brevipes* on leaves of *F. elastica*. Koorders says this is indistinguishable from *G. elasticae* C. & M.

6. *Gloeosporium elasticae* C. & M. on leaves of *Fiscus elastica*.

7. *Glocosporium Beniaminae* Scalia on leaves of *F. Beniaminae* in Sicily.

8. *Gloeosporium fructigenum* Berk. in fig fruits, Sussex, England, 1864.[4]

Only one of these species is recorded as occurring upon the fig, *Ficus Carica*, itself, nor do any of these species seem to be the species found upon the fig in this State.

Aside from the presence of setae in the species under discussion, it also differs from each of the various species of *Gloeosporium*. Its spores are smaller than those of No. 5 and its basidia are narrower and shorter. Its spores are much smaller and of very different shape than those of No. 7. Its spores differ in shape and size from those of No. 6 and are smaller than those of No. 8.

This species differs clearly from each of the species of *Colletotrichum* also. Its setae are much shorter than those of No. 3, which also is separated from it by its crescent-shaped spores. It is distinguished from Nos. 1 and 2 by its shorter setae and smaller uncurved spores.

It is possible that this disease is the same referred to as an undescribed *Colletotrichum* in the Year-book of the U. S. Department of Agriculture, 1907, p. 581, or that it is identical with a *Colletotrichum* of fig fruit collected at Berkley, Va., in 1905 and thought by Mrs. Flora Patterson to be an undescribed species, though it is impossible in the absence of any description or specimen to be sure in this regard.

It seems desirable to recognize this as a new species of *Colletotrichum*, for which we propose the following name and characterization drawn from the fungus as growing upon the nearly ripe fig:

Colletotrichum Carica, n sp.

Acervuli brown, becoming black, hemispherical, numerous, small, 85 to 250 μ in diameter, bearing one to twelve or often no setae, setae long, irregular, slender, acute, dark throughout, rigid, septate, 2 to 6 μ, thick by 22 to 106 μ long; conidiophores, slender 1 to 2 μ wide, 45 μ long hyaline; spores, regular, oblong, obtuse, continuous, hyaline, 3.5 to 6.6 μ by 8.7 to 20 μ.

---

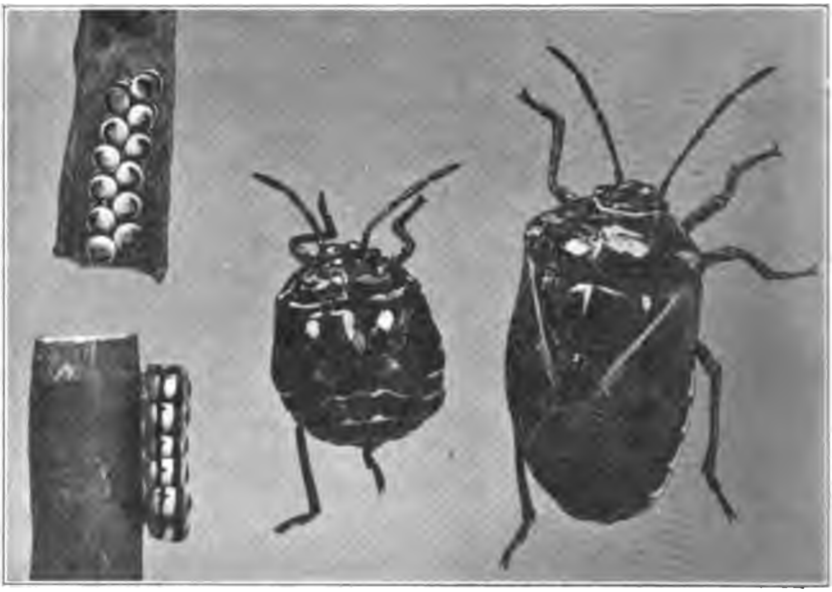
[3] Now regarded as Neozimmermania Elasticae (Koodors, Bot. Unt Verh of Koninktijke Akad. v. Wetenschappen te Amsterdam Dert. XIII, No. 4, 1907).

[4] Cooke. Jour. Roy. Hort. Soc., 28, p. 29.

HARLEQUIN CABBAGE BUG (MURGANTIA HISTRIONICA).[1]

By R. I. Smith.

As an enemy of collard, cabbage, turnip, and related plants throughout the Southern States, none surpasses the harlequin bug in persistence and general destructiveness, in spite of the numerous remedies that are constantly printed in bulletins, agricultural papers and journals. The general failure to control this pest is partly the result of neglect, but is due largely to the farmers' lack of information concerning how the insect feeds, its rate of increase and remarkable power of surviving under unfavorable conditions. Realizing this situation, the writer undertook, in 1908, a thorough study of the life-history and habits of this insect with a view to determining definitely the best methods of control. The results of this work, recorded in the following pages, reveal some facts hitherto unknown, which furnish a sound basis for the remedial suggestions which are made a part of this article.



Examination of the literature shows that some early writers make very erroneous statements concerning the number of annual generations and rate of increase. Later writers have frequently repeated these questionable statements, and, in general, entomologists have failed to make definite and complete observations on the most vital points in connection with this insect's life-history and habits. The writer's studies, although not complete in every respect, have resulted in obtaining information of considerable economic importance, because they show how and why the pest may be controlled by hand-collecting, spraying, and correct cultural methods.

---

[1] Terrapin bug, collard bug, fire bug, calico bug, and sometimes other names of local adoption, are applied to this insect; but harlequin cabbage bug is the name by which it is most widely recognized in the various States where it occurs.

DESCRIPTION.

The illustration shows the general appearance of eggs, young and adults. The latter have well-developed wings, with the dark portions black or metallic blue, and the lighter portion bright yellow in freshly transformed bugs, and red in the older individuals. The younger stages lack wings and vary somewhat in shape and appearance, in accordance with their age, but are readily recognized.

The eggs are set on end in masses of ten to fourteen, and resemble miniature barrels bound with two black hoops, as shown in the illustration.

GENERAL LIFE-HISTORY AND HABITS.

Winter Stage.—Harlequin cabbage bugs pass the winter in this state only as strong, mature adults, protected by whatever cover they happen to find. It seems probable that most of the bugs seek shelter in the fields where they were last feeding, but many find more favorable hibernating quarters under fences, buildings, rubbish piles, and in adjoining woodlands or thickets. A large number of the bugs that seek winter protection are unable to secure a favorable place, and consequently die, but a sufficient number survive, as is evidenced by their abundance each spring.

Eggs deposited in the fall too late to hatch, or bugs that fail to reach maturity before winter commences, do not live until spring.

Earliest Appearance.—The first warm spring days find the bugs issuing from their hiding quarters, and they may become active during a prolonged warm period in winter, but in 1908 it was the last of March before many bugs appeared. For the season's work the first definite observations and notes were made April 4, 1908, at West Raleigh, where all the work herewith recorded was done. The season was a little late, but bugs were then present in considerable numbers, although no eggs were discovered until a few days later, and the first young were found on April 14; hence this date is considered as approximately the beginning of the first seasonal generation. Some springs may bring forth adults at an earlier date.

Feeding and Mating.—Mating does not ordinarily take place until the bugs have fed from a week to ten days, but the first egg mass may be deposited the next day after mating. The females under observation in the laboratory mated usually the day before each egg mass was laid, but those confined without males laid just as regularly and in the normal manner. Mating occurs during the day, the pairs often remaining together several hours.

Egg-laying Habits.—It is generally supposed that twelve is the normal number of eggs deposited in each mass, being placed on end in two parallel rows of six each, closely cemented together, the eggs usually alternating like the cells of a honeycomb. As a matter of fact, the eggs are always placed on end, but a greater number are laid in more or less irregular masses than in two parallel rows of six each. Out of ninety-four egg masses laid in the laboratory by females under observation, sixty-two were irregular in form, but contained twelve eggs each, while only nineteen were regular with twelve eggs each, and thirteen masses varied in numbers from eight to fourteen. Twelve eggs for each mass is undoubtedly the average number, as evidenced by the fact that three females laid eleven once and thirteen in the following mass, while another laid ten and then fourteen eggs. In all instances observed where less than eleven were laid at one time, or where eleven eggs were deposited two or three times in succession, the female died shortly afterward.

The table—giving the egg-laying record—shows how often the egg masses are deposited, and it will be noticed that this time varies from two to fifteen days, but on an average of one mass about every four days.

Concerning the time consumed by a female in depositing the eggs, a marked regularity exists. I have watched several egg masses deposited and find it takes about thirty minutes to deposit twelve eggs. A quotation from notes made at the time will serve as an illustration:

"April 15, 1908, 4 P. M.—I have just watched and timed female of Pair No. 13, deposit a mass of twelve eggs. At 2:50 P. M. she was observed in the position assumed when about to commence deposition. She was apparently straining the abdominal muscles, and moved the abdomen up and down occasionally, during which process she frequently stroked the tip of her abdomen with either hind leg. During this process a drop of moisture appeared probably to serve as a glue for the first egg. At 2:56 P. M. the first egg was dropped, and the remaining number, making a regular mass of twelve in all, were deposited from 2:56 until 3:25, when the last egg appeared, or exactly twenty-nine minutes after dropping the first egg. Counting the six minutes that she remained in position preparatory to laying the first egg, it required thirty-five minutes for the whole process. The time elapsing between the appearance of each egg is almost exactly two and one-half minutes."

Incubation of Eggs.—The incubation period varies greatly with the temperature. Eggs deposited from April 9 to 15 required an average of eleven days, some requiring twelve days, while from May 12 to 21 the average was about six days. In hot summer weather they may hatch on the fourth day.

EGG-LAYING RECORD OF HIBERNATED INDIVIDUALS.

As already stated, these observations were commenced on April 4, when a very few eggs may have been present in the fields; hence of the fourteen pairs selected for the egg-laying record some may have deposited one mass. For this record, pairs were taken and confined in large glass vials with suitable food and a strip of blotting paper to absorb surplus moisture. It is my opinion that too little absorbent was used, the lack of which caused the premature death of some individuals. Six pairs were taken on April 4, and eight pairs on April 7. They were given fresh food (collard or cabbage) daily and the number of eggs were counted and removed each morning. As the eggs are laid during the daytime, the record is always one day behind as regards the actual date when the eggs were laid.

The shape of the egg mass, whether regular or irregular, and number of eggs, are represented in vertical volume in table, the letter "R" meaning regular, that is, two uniform parallel rows ("12-R" meaning twelve eggs in two rows of six each) and "I" meaning irregular ("12-I" meaning twelve eggs in an irregular mass).

EGG-LAYING RECORD OF MURGANTIA HISTRIONICA. HAHN.

Daily Record of Fourteen Females of the Hibernated Generation.

Date.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908. April 4														
5														
6														
7	12–I	12–R	12–R		12–I									
8				12–I		12–I								
9			12–I			12–I		12–R	12–I	12–I				
10	12–R	12–I			12–I									12–I
11			12–I				12–I			12–I		12–R	12–R	
12				11–I							12–I			
13	12–R							12–R	12–I					
14		12–I	12–I		12–I	11–R				12–I				12–I
15														
16				13–R			12–I		12–I		12–I	12–I	12–R	12–I
17										12–I				
18														
19			12–I					12–I						
20	12–I	12–I			12–I	11–R						12–I		
21				12–R			12–I		12–I		12–R			12–I
22	12–I							12–R						
23			12–I		12–I				12–I			12–I		Died
24													12–I	
25		12–I				12–R				12–I	12–R	Died		
26				12–I					12–I				Died	
27	12–I		12–I		12–I	11–R	10–R	11–I						
28		5	Died							4				
29		3						13–I		Died	Died			
30								Died	12–R					
May 1	12–I			8–R										
2				Died	12–I									
3						Died								
4														
5		2												
6														
7		Died					14–I							
8														
9														
10									12–I					

EGG-LAYING RECORD OF MURGANTIA HISTRIONICA. HAHN.—*Continued.*

Date.	Daily Record of Fourteen Females of the Hibernated Generation.													
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908. May 11														
12	12–I				12–R									
13														
14									11–R					
15	11–R													
16					12–I				Died					
17														
18							12–R							
19	12–I				12–I									
20							12–I							
21														
22	12–I													
23					12–I									
24														
25	Died						12–I							
26														
27							12–I							
28					12–I									
29							12–R							
30														
31					12–I									
June 1														
2														
3							Died							
4					11–I									
5														
6														
7														
8														
9					12–I									
10														
11					Died									
Total Egg Masses	11	8	7	6	15	6	10	6	9	6	4	4	3	4
Total Eggs	131	70	84	68	179	69	120	72	107	64	48	48	36	48

From the above record, we determine that the length of life of individuals varied from twenty-two to sixty-nine days in confinement; also that the number of eggs deposited varied in about the same proportion. As a matter of fact, it is probable that those females dying before depositing at least six egg masses would have lived longer under more favorable conditions. At the same time Nos. 2, 4, 8 and 10, females that deposited eggs quite irregularly toward the last, in all probability died of natural causes; hence it would seem that by counting the average of the number of eggs obtained from females depositing at least six egg masses, we would have a fair average number that might be laid under normal or natural conditions. Granting this to be a correct supposition, we have ninety-nine as the average number of eggs laid by each hibernating female.

EGG LAYING OF SECOND GENERATION.

To serve as a check on the egg-laying record of the hibernated generation and to determine which, if either, lays the greatest number of eggs during their lifetime, an attempt was made to get a similar record for individuals of the second seasonal generation. For this experiment nymphs in the last stage of development were collected from the field, taken to the laboratory, reared to adults and from them, on August 10, fourteen pairs were selected and isolated in 4-ounce bottles with suitable food. Unfortunately, the mortality among these specimens was quite high, due, I am now convinced, to an excess of moisture accumulating in the bottles. Consequently the record is not as satisfactory as might be wished for, but at the same time is rather interesting.

EGG RECORD OF FOURTEEN FEMALES IN SECOND GENERATION.

Out of this number separated on August 10, seven died between August 24 and 27, after laying from twelve to thirty-six eggs each. Three more died on August 31, September 4, and September 7, respectively, each one having laid thirty-six eggs. On September 21 another female died, at forty-four days of age from maturity, after laying four egg masses containing forty-six eggs in all.

There remained only three females out of the original fourteen, and as they laid a larger number of eggs and lived so much longer, their individual record seems to be of particular interest, and is as follows:

The female of Pair No. 8 became adult on August 7 or 8, lived until October 5, or fifty-eight days, and deposited seventy-two eggs, or a mass of twelve eggs each, on the following dates: August 20 and 24, September 8, 17, 21, and 26.

The female of Pair No. 9 became adult August 8, lived until October 10, or sixty-three days, and deposited seventy-one eggs, or a mass of twelve eggs each (except once, when only eleven eggs were found), on the following dates: August 20 and 29, September 2, 10 (eleven eggs), 17 and 21.

The female of Pair No. 10 became adult August 7 or 8, lived under observation until October 10, when she escaped, after depositing eighty-four eggs or seven masses of twelve eggs each, on the following dates: August 20 and 29, September 7, 11, 20, 25, and 29.

As already stated, it seems probable that the females that died so soon after maturity were killed by excessive moisture in the bottles. In other words, the moisture caused them to get fastened to the sides of the bottles, where they died in their struggle to loose themselves. As this experiment was followed closely, I feel confident in concluding that the average number of eggs deposited by the second brood is six or seven masses of twelve eggs each, or from seventy-two to eighty-four eggs. This is less than the average for the hibernating brood.

LENGTH OF LIFE CYCLE.

There is some variation in the duration of the young stages, particularly the 4th and 5th instars. Chittenden records the life cycle for bugs hatching in March, as seventy days, including the egg stage, which covered eleven days. My record of bugs that hatched on August 24 and 25 shows the life cycle, exclusive of the egg stage, covered from fifty-seven to sixty-five days.

The following table shows the record of four individuals which were kept in the unheated laboratory.

LIFE CYCLE OF FOUR INDIVIDUALS.

No.	Hatched.	End of First Instar.	End of Second Instar.	End of Third Instar.	End of Fourth Instar.	End of Fifth Instar. Becoming Adult.	Total. No. Days.
1...	Aug. 25	Aug. 30–31[1]	Sept. 7–8[1]	Sept. 15	Sept. 27	Oct. 23	59
2...	Aug. 25	Aug. 30–31[1]	Sept. 7	Sept. 15	Oct. 2	Oct. 29	65
3...	Aug. 24	Aug. 30	Sept. 7–8[1]	Sept. 16–17[1]	Sept. 26	Oct. 20	57
4...	Aug. 24	Aug. 30	Sept. 7–8[1]	Sept. 16–17[1]	Sept. 30	Oct. 27	64

As evidence that the duration of the fourth and fifth instars may vary, it is only necessary to study the above table, and as further proof compare these dates with the time recorded by Chittenden, as above mentioned. He states: "The first or egg stage covered eleven days. The time from the hatching of the eggs until the first molt gave the first larval instar or nymph period seven days; the second instar required thirteen days; the third, eight days; the fourth, fourteen days; while the fifth or pupal instar covered seventeen days—a total of seventy days or ten weeks."

The life cycle of the first generation was not as long, and probably means that the food supply governs to some extent the rapidity of growth. The recorded dates are given below.

NUMBER OF GENERATIONS ANNUALLY.

Three full generations, and perhaps a partial fourth, are all that are produced in the vicinity of Raleigh. This assertion is based on notes secured by careful observation resulting in a discovery that the bugs maturing after September 1 do not lay eggs the same season, but, on the contrary, live during the fall, and hibernate when cold weather commences. Considering the large number of young bugs usually present in the fields during November, it is not strange that a full fourth and fifth generation has been credited to this species. Indeed, one writer has stated that there may be seven or eight. Having learned, however, that females may live and continue depositing eggs for more than two months, the presence of young bugs the last of November may be accounted for, and safely classed as belated individuals of the third generation.

---

[1] With these the molt occurred some time between 5 P. M. and 8:30 A. M. *the following day.*

In the spring of 1908 the earliest individuals of the first brood became mature on May 25, and deposited eggs nine days later. This showed that the first generation took at least fifty-one days, exclusive of the egg stage, to become full grown and commence to deposit eggs. At this rate, allowing four days for eggs to hatch, the first individuals of the second generation became mature fifty-five days later, or on July 29, and this would throw the first adults of the third brood well into September.

It should be understood that many eggs are laid during September, October, and even November, but my observations show that these are laid by females maturing before September 1. As a matter of fact, the generations overlap completely after the last of May, and there may be a difference of over two months in the age of individuals of each generation.

PREVENTIVE AND REMEDIAL MEASURES.

The harlequin cabbage bugs are by no means easy to control, but the possibility of preventing their presence in destructive numbers depends largely on the individual farmer or gardener. While the adults fly readily, they usually confine themselves to one locality as long as there is sufficient food, and for this reason the gardener who makes a vigorous fight against them in his own fields may depend upon it that no serious reinfestation will result from neighboring fields unless they happen to lie very close together.

The recommendations that follow are based upon the known habits of this pest with a view of taking advantage of their weakest points.

Winter Treatment.—Knowing that the adults hibernate during winter, the practice of clean farming suggests itself as a valuable preventive measure. It is a well-known fact that this pest is reduced to small numbers on large cultivated areas that are properly cleared of remnants of old crops, followed by fall, winter or early spring plowing. A good illustration has come under the writer's observation in the case of the farm of the Central Hospital, located at Raleigh. This farm embraces several hundred acres of cultivated land, of which a good many each year are devoted to the growth of cabbage, collards, and turnips, and which furnish extensive feeding ground for the harlequin bug. The manager advises me that he formally attempted to save seed from these crops, and while doing so the insects were very hard to control, but that he has now abandoned this, and consequently is enabled to get his fields cleaned up early in the fall. The result is that the bugs are not troublesome, owing to the small numbers that survive the winter. Similar results have been obtained on the farm of the Agricultural College. Farmers who allow a quarter or half acre of worthless plants to remain during the late fall months as food for harlequin bugs are simply inviting trouble.

Early Spring Destruction.—As a preventive measure, the destruction of the bugs that first appear in spring should be given first importance. We could not consistently urge this practice if the bugs commenced egg laying when they first appeared, but we know that about two weeks' time is devoted to feeding and to mating before eggs are deposited. As a general rule, the bugs appearing earliest congregate on a few plants, flowering mustard, turnips, or collards furnishing favorite feeding grounds. From such places they should be collected by hand, or killed with pure kerosene in case the plants are worthless. The true value of this practice is illustrated by considering the following:

Rate of Increase.—As an illustration of the benefit derived from destroying the bugs before they have commenced to lay eggs, we see by referring to the egg-laying record, that each female deposits an average of about one hundred eggs. There are three full generations annually. Suppose we kill a single female and thus prevent one hundred young of the first generation, of which one-half might be females. If these fifty reproduced at the same rate the second generation would number 5,000, and counting only one-half of these as females, each capable of producing one hundred young, the third generation would reach the enormous number of 250,000, the progeny of one female in a single year. We can divide this number by 100 and still have 2,500 as the number of bugs prevented by killing one individual when she first appears in spring.

During the warm summer months a large per cent of the eggs are destroyed by a minute parasite in the form of a tiny black fly; but as a general rule, they do not become abundant until the first generation is well developed, so that the destruction of the bugs that produce that generation will result in greater benefit than similar work later in the year.

Hand Picking.—During the summer months harlequin bugs are liable to occur in small numbers, even where the previous recommendations have been followed, and to prevent their increase, collecting by hand is the most profitable remedy. Progressive truckers employ children for this work and find it pays better than to let the bugs increase until spraying becomes necessary.

Spraying.—Kerosene emulsion of 15 per cent strength may be used to kill small or half-grown bugs, and is also somewhat effective against the mature forms. However, when the bugs are sufficiently numerous to make spraying profitable, much injury has usually been done, and this situation should be avoided by the methods already suggested.

When kerosene emulsion is employed it should be applied with a good spray pump, forcing the spray under high pressure, knocking the bugs to the ground and covering them where they lie. Some adult bugs will always survive, necessitating a second or third treatment.

Harlequin bugs feed entirely by sucking, and arsenical poison sprays are therefore useless. Kerosene emulsion kills by contact, so unless the individual bugs are hit by the spray, they will not be killed.

Fall Destruction.—Toward the end of every season, harlequin bugs frequently become numerous on remnants of crops that are of little or no value and usually no attempt is made to destroy them. From what has already been stated, it is evident that they are the ones that will pass the winter. Here, then, is an opportunity to destroy large numbers that would otherwise have to be collected the following spring; in this case the suggestion is again based on the life-history of the insect, that is, the fact that those maturing after about September 1 do not lay eggs the same fall. During October and November, there is ample time to destroy the bugs to protect the following year's crop.

In the opinion of the writer, time put in this fall destruction will prove to be well spent and should be considered as an essential part of the fight against this pest.

This work may be accomplished by hand collecting, spraying or cleaning off remnants of crops, followed immediately by deep plowing. Every adult killed in the fall may mean one less the following spring, and the aim should be to prevent their going into hibernating quarters.

IS NEOCOSMOSPORA VASINFECTA (Atk.) SMITH, THE PERITHECIAL STAGE OF THE FUSARIUM WHICH CAUSES COWPEA WILT?

By B. B. HIGGINS.[1]

One of the first wilt diseases to be attributed to the Fusarium type of fungi was a disease of cotton described by Atkinson[2] in 1892. The wilting of the cotton was attributed to the plugging of the vessels of the plant near the base of the stem by the mycelium of a fungus. This fungus was isolated and described by Atkinson[2] as a new species of Fusarium under the name *Fusarium vasinfectum.*

Atkinson also found a Fusarium on the surface of some of the sick plants, but considered this a saprophyte distinct from the internal fungus.

A few years later (1894-1899) Erwin F. Smith made a much more extensive study of the wilt-producing Fusaria on cotton, also on watermelon and cowpea.[3] He found an internal fungus plugging the vessels of the stems, and producing in them (melon and cowpea) short hyaline, nonseptate (or occasionally, once or twice, septate) spores, microconidia. The Fusarium was found in all three host plants, cotton, watermelon, and cowpea, and was considered by Smith to be specifically identical with *Fusarium vasinfectum* Atk.

After the plants infected with internal fungus had died, another spore form, "macroconidia," appeared on the surface of the stems. This form is described by Smith[1] as consisting of lunulate, 3 to 5 septate spores, 30 to 50 by 4 to 6 mu., which are borne on the surfaces of dead stems in immense numbers or on innumerable, small, oval, or hemispherical conidia beds which arise from the internal mycelium and consist of compact, irregularly branched, short conidiophores. The spores, when germinated in water or in acid or alkaline agar or in very moist air, are said to produce conidia indistinguishable from those borne by the internal fungus.

The enlarged cells in the hyphæ of the fungus described by Atkinson as resembling gemmæ were also noted by Smith on stems of watermelon, and cultures of the fungus from melon and cotton and were regarded as clamydospores.

Smith also found red perithecia growing on the roots and stems of cotton, watermelon, and cowpea.

All four of these fungous forms were considered by Smith to be stages in the life-history of one fungus, which he named from its ascogenous stage *Neocosmospora vasinfecta.*

---

[1] [The investigation upon which this article is based was begun by Mr. Higgins, at the suggestion of Dr. Stevens, to form material for a Master's thesis. The preliminary studies revealed a problem of unexpected significance and led to modification of the original plan and to the devotion of a portion of Mr. Higgins' time as laboratory assistant of the Experiment Station to the completion of the investigation. The research was thereafter carried on under the direction of Dr. Stevens, partly as Station work and partly in pursuance of college study.—DIRECTOR.]

[2] Some Diseases of Cotton. Ala. Sta. Bul. 41, pp. 19-29.

[3] Wilt Disease of Cotton, Watermelon, and Cowpea. Bul. No. 17, U. S. Dept. of Agr., Div. of Veg. Phys. and Path.

Smith's conclusion as to the genetic relationship of these fungous forms has been generally accepted, although only a very few writers have reported actually finding the perithecia,[2, 17] and no one, so far as I can find, has by means of pure cultures corroborated Smith's conclusions.

Whether Smith did or did not succeed in producing perithecia from the internal fungus taken from the stems of the cowpea, is not quite clear. In Bulletin 17 (Div. of Veg. Phys. and Path., U. S. Dept. of Agr., p. 11) he says: "No perithecia ever developed in any of the cultures made from internal or external conidia taken from the cotton or watermelon."

Thus, although denying perithecial production by conidia taken from watermelon and cotton, he does not deny perithecia production by conidia from the cowpea fungus. From this, one might be led to infer that perithecia were obtained from conidia taken from the cowpea. The only positive statement of the production of perithecia from conidia is made on page 10 of the above-mentioned bulletin, where he says: "Perithecia have also been produced from 150 or more microconidia. They were isolated by the poured plate method, the material being derived from an agar culture about two weeks old which was made from ascospores." No statement is made as to whether the culture producing these ascospores was obtained originally from the internal fungus or from the outer perithecial fungus.

With these facts in mind, the present work was begun in the fall of 1908 in the laboratory of the Station, to learn so far as possible the exact conditions under which perithecia are produced, and if possible to obtain perithecia from pure cultures of the internal fungus from cowpea stems.

There has long been much question as to why certain imperfect fungi, *e. g.*, *Colletotrichum gossypii*, *Glœosporium fructigenum*, etc., produce perithecia abundantly under almost any conditions, while other strains of what is apparently the same fungus do not produce perithecia at all. Again, the perithecia-producing power seems to come and go in the same strain. It was hoped by the study of selected pedigree cultures to throw light upon this point regarding the forms under discussion.

---

[1] Smith lc.

[2] Butler, E. J., Fungous Diseases of India in 1903. Ztschr. Pflanzenkrank. 15 (1905), pp. 44-48.

[3] Delacroix, G., Cotton Disease in Egypt. Agr. Prat. Pays Chauds, 2 (1902), No. 8, pp. 135-143; Jour. Agr. Trop. (1902), No. 14, pp. 231-233.

[4] Delacroix, La Maladie des osillets d'Autibes. 1901.

[5] Delacroix and Maublanc, Encyclopedia Agricole Maladies Parasitaires des Plants Cultivates (*Neocosmospora vasinfecta*), pp. 333-334.

[6] Duggar, B. M., Fungous Diseases of Plants, pp. 233-239.

[7] Evans, G., Cotton Wilt in Central Provinces. Agr. Jour. of India, 3 (1908), I, pp. 78-80.

[8] Fletcher, F., Notes on Two Diseases of Cotton. Jour. Khediv. Agr. Soc. and School Agr., 4 (1902), 6, p. 42.

[9] Jaczewski, A. von, On the Occurrence of the Wilt of Sesame. Ann. Mycol., I (1903), I, pp. 31-32; abs. in Bot. Centbl. 92 (1903), 23, p. 543.

[10] Lewis, A. C., Black Root Diseases of Cotton in Georgia, and Its Control. Ga. Bd. Ent., Bul. 28.

[11] Malkoff, K. A., Plant Diseases and Other Injuries to Cultivated Plants. Ghod. Otchet. Drzhav. Zeml. Opitna Stanz. Sadovo. (Jahresber. Staatl. Landw. Vers. Stat. Sadovo) 4 (1906).

[12] Orton, W. A., Some Diseases of the Cowpea. Bul. 17, Bur. of Plant Industry, U. S. Dept. of Agr., pp. 9-23.

[13] Orton, W. A., A Study of Disease Resistance in Watermelons. Abs. in Science, n. ser. 25 (1907), 634, p. 288.

[14] Orton, W. A., Cotton Wilt. U. S. Dept. of Agr., Farmers' Bul. 333, pp. 5-54.

[15] Reed, H. S., Parasitism of *Neocosmospora vasinfecta* Science, n. ser. 23 (1906), 593, pp. 751-752.

[16] Smith, R. I., and Lewis, A. C., Black Root Disease of Cotton. Ga. Bd. Ent., Bul. 22, pp. 237-275.

[17] Sorauer, P. Handbuch der Pflanzenkrankheiten, Dritte Auflage, p. 204.

Abundant material was found in the fields of the College and Station farms. Externally, the diseased cowpea plants presented the characteristic wilted appearance as fully described by Orton.[1] Internally, the woody portion of the stem near the ground was browned and the characteristic conidia-bearing mycelium was found in the vessels.

After the plants had died, innumerable small, roundish, salmon-colored spore clusters appeared on the surface of the stems. These tufts were made up of large sickle-shaped, 3-5 septate spores, borne on the ends of short, irregularly branched hyphæ (Figs. 2 and 3).

For convenience in distinguishing the different fungous forms found in or on the cowpea stems, the fungus found in the ducts of the plants will hereafter be designated the "internal Fusarium"; the spore clusters found on the surface of dead stems will be called the "external Fusarium"; and the ascigerous form will be mentioned as such.

The work for the first month was confined almost entirely to searching for red perithecia, described by Smith.[1] The stems and roots of hundreds of sick or dead plants from various fields were examined. A great many stems and roots were also brought to the laboratory and placed in tubes with the hope that perithecia would develop upon them; yet, all these early searches for perithecia were unsuccessful.

On October 31, 1908, pure cultures of the internal Fusarium were obtained by aseptic transference of the mycelium from inside the stems to plates of cowpea-leaf agar.

From these original cultures very numerous transfers were made to study the effect of different media upon the fungus. The fungus (internal Fusarium) was grown on cowpea agar, cowpea-leaf agar, carnation agar, Irish potato, rice, and stems of green cowpeas.

Of the last-named medium more than two hundred tubes were prepared and inoculated, as follows:

Stems of almost mature cowpea vines were cut in pieces 10-12 cm. long and placed in test tubes containing about 3 cc. of water. They were then autoclaved at 120° C. for twenty minutes. All were inoculated with mycelium of the internal fungus.

This medium, it would seem, should give the nearest possible approach of any medium to the natural food and environment of the fungus. The ascigerous stage never appeared, however, although the tubes were kept and examined at intervals for more than four months. Neither did the ascigerous stage appear on any of the other media.

On the same day that the original isolation was made (October 31) pieces from three diseased stems were placed in test tubes and set away in the laboratory.

The perithecia of a great many ascigerous fungi (Melanospora being specially abundant) developed on these stems. After about two months a few bright-red perithecia appeared on one of the stems. On examination, they were found to agree in every particular, size, shape, color, and general structure of perithecia, of asci, and of spores, with Smith's[2] description of the perithecial stage of *Neocosmospora vasinfecta*.

On January 16 one of these perithecia was crushed, placed in a tube of melted pea agar, and poured into a Petri dish. When the ascospores began to germinate, one of the germinating spores was lifted out with the aid of a dissecting microscope, and transferred to another plate. In about a week from the time of sowing spores very small colorless perithecia appeared around the center of the colony; the second day after the perithecia were first noticed they began to turn red, and by the end of another week they were of a bright-red color and contained ascospores. Short, hyaline, continuous or once septate conidia (microconidia of Smith)[1] were also produced in abundance. This colony was kept pure, and from it the material for the first transfers in pedigree cultures was obtained. It therefore constitutes generation No. 1 in this experiment. In all, fifty-four colonies were produced from this one perithecium, and every colony produced both perithecia and conidia.

---

[1] Orton, lc.
[2] Smith, lc.

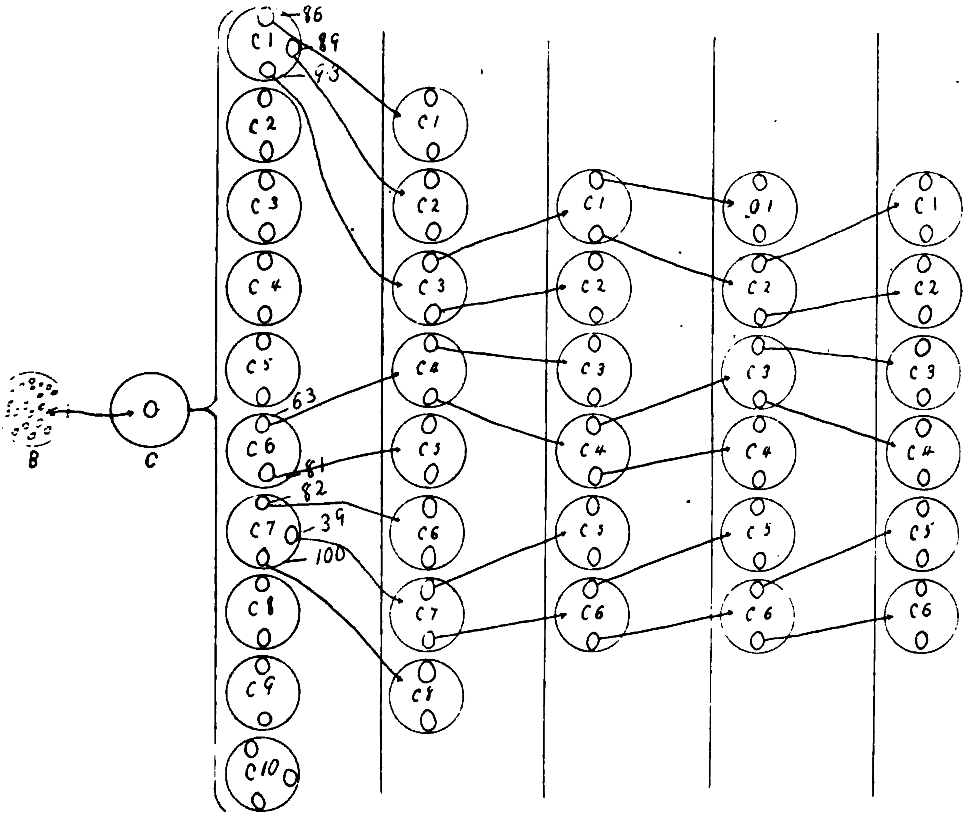


Fig. 1.—Pedigree diagram, showing method of recording the pedigrees of the cultures; *b*, culture from original perithecium; *c*, single colony from *b*, generation No. 1. Numbers within the circle are the numbers of the plates.

Pedigree Cultures.—By pedigree cultures is meant, cultures in which the parentage (whether ascosporic, conidial, or mycelial) of any colony can readily be traced back to the perithecium taken from the cowpea stem. Concerning these pedigree cultures, records were kept of all marked variations in every colony. The parentage records were kept by means of diagrams, which were meant so far as possible to show graphically the manner in which each transfer was made (Fig. 1).

---

[1] Smith, lc.

It was suggested by Smith that remoteness of origin from the ascospore might interfere with the perithecia production of this fungus. It was also suggested to the writer that by taking advantage of small variations of the fungus in the direction of lessened perithecia production, it might be possible to produce a strain which would not produce perithecia at all.

To test these two points, transfers to new media were made from the original colony (generation No. 1) in three ways:

1. Bits of mycelium bearing no conidia were transferred from the extreme edge of the colony.
2. Conidia were transferred by adding a drop of water to a conidial region, then with platinum loop transferring an oese of this water to new media.
3. Ascosporic transfers were made by crushing perithecia in sterile water on a sterile slide, then after careful examination, under a microscope, to see that no conidia were present, transfers were made with a loop to new media.

Thus, from the single colony of generation No. 1 the following transfers were made: January 30, seven mycelial transfers; February 6, ten conidial (microconidia) transfers; and February 11, fourteen ascosporic transfers. The resulting cultures constitute generation No. 2.

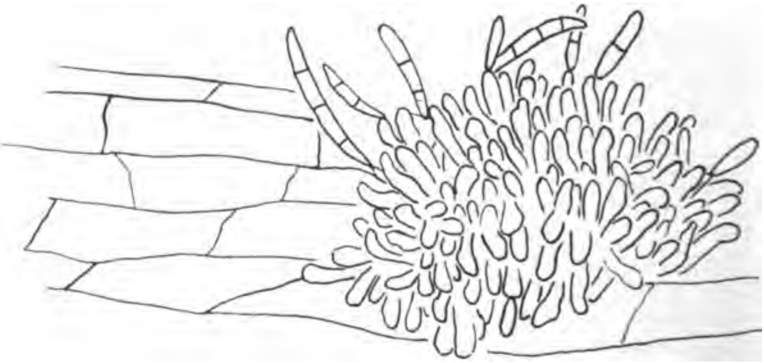


FIG. 2.—Conidia bed from surface of cowpea stem killed by wilt; showing tufts of conidia-bearing hyphæ and sickle-shaped conidia, macroconidia.

On February 11, fourteen mycelial and twenty-eight conidial transfers were made from the seven mycelial cultures of generation No. 2. On February 22, sixteen mycelial and sixteen conidial transfers were made from eight of the conidial cultures of generation No. 2.

In these eight colonies there was a slight variation in number of perithecia produced per colony, due possibly to bacterial contamination in some of the plates. Colony No. 1 produced eighty-six perithecia; No. 2, ninety-three; No. 3, eighty-nine; No. 4, sixty-three; No. 5, eighty-one; No. 6, eighty-two; No. 7, thirty-nine, and No. 8 produced one hundred perithecia. No. 4 and No. 7 were both badly contaminated with bacteria. Cultures of both conidial and mycelial origin produced perithecia uniformly and in apparently equal numbers.

Since this time only three straight lines of transfers have been made, that is, mycelial transfers made from mycelial colonies, conidial transfers from conidial colonies, and ascosporic transfers from ascigerous colonies. This has continued in case of the mycelial and conidial lines through six generations, and the ascosporic line has been carried through five generations.

The mycelial and conidial transfers were made about every two weeks, when the plate was nearly covered by the colony. The ascosporic transfers were not made until spores were fully mature, emerged naturally and collected in dark-brown masses around the osteolum, which occurred in about three to four weeks after inoculation.

So far there has been no apparent loss of power to produce perithecia in either the conidial, mycelial, or ascosporic lines, nor any marked variation in this respect.

To test the effect of different media on perithecia production, inoculations were made onto plain agar, cba[1]., cba+sodium asparaginate+glucose, cba+starch, and cba+glucose. All these media produced perithecia. They were produced most abundantly on cba+sodium asparaginate+glucose and least abundantly on plain agar.

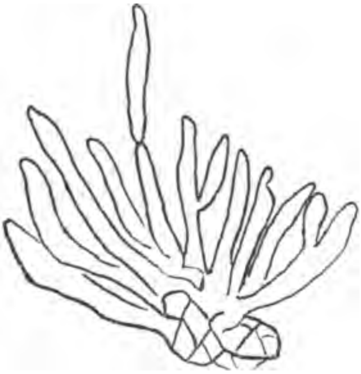


FIG. 3.—Small portion of conidia bed, showing irregular branching of hyphæ.

To see if these changes in perithecia-producing power were permanent, cross inoculations were made upon the two media. Two plates of plain agar and two of cba+sodium asparaginate+glucose were inoculated from a colony which had produced nine perithecia per square centimeter on plain agar. A like number of plates was inoculated from a colony which had produced one hundred and seventy perithecia per square centimeter on cba+sodium asparaginate+glucose. Practically the same number of perithecia was produced from each inoculation, six per square centimeter on plain agar and one hundred and sixty-seven per square centimeter on cba+sodium asparaginate+glucose.

These results indicate that the amount of nourishment does not affect permanently the perithecia-producing power of the fungus. It was noticed, further, that the number of perithecia produced varied about proportionately to the amount of mycelial growth. That is, when grown on a medium rich in nutrients (such as cba+sodium asparaginate+glucose) the fungus made a luxuriant growth of mycelium and produced perithecia abundantly, while on media poor in nutrients (such as plain agar) it made a thin, scanty growth of mycelium and produced proportionately few perithecia.

Alkaline Rice.—Tubes of rice were prepared and made alkaline as follows: 8 grams of rice were weighed into each tube, two cubic centimeters of a saturated solution of sodium carbonate added, and autoclaved for twenty minutes at 120° C. These tubes were then inoculated with ascospores. After fifteen days a slight whitish growth could be seen on the surface, and in another week it had covered the surface of the rice. At the end of sixty days a grayish white to dark steel-gray stroma covered the surface of the rice and an abundance of small colorless conidia was found. The stroma, however, showed no perithecia even under careful microscopic examination. At this time (sixtieth day from inoculations) some of the mycelium with conidia was transferred to plates of cowpea-leaf agar. In a few days perithecia appeared in abundance on the new growth. On the ninetieth day transfers were again made from the alkaline rice to agar, with the same results.

---

[1] cba signifies Chemical Base Agar. For details of composition, see article by Stevens and Hall, "Variations of Fungi Due to Environment." Bot. Gaz. 48; pp. 1-30.

The ascigerous fungus was grown on a great many other media, viz., asparagus agar, carnation agar, steamed potato (both Irish and sweet), rice, steamed cowpea stems (both green and cured), and gelatine. Perithecia were produced abundantly on all these media.

EFFECT OF HEAT UPON PRODUCTION OF PERITHECIA.

Twelve agar plates were inoculated; six were placed in an incubator at 27° C. and the other six were left in the open room.

Perithecia appeared on the plates in the incubator in forty-eight hours, while they did not appear on the other plates until the sixth day; but the ultimate number of perithecia produced was practically the same in each case.

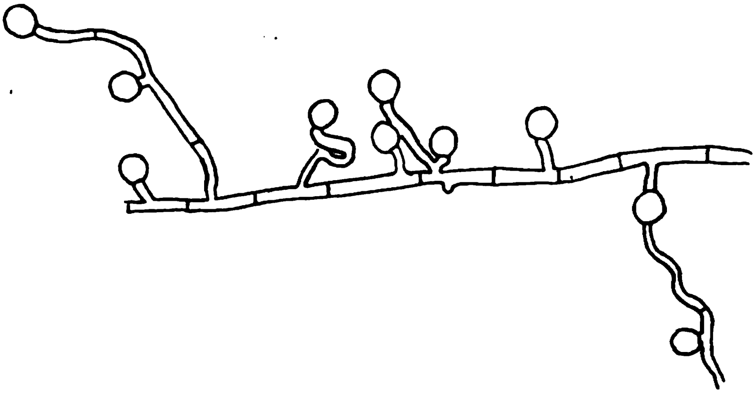


FIG. 4.—Mycelium, bearing several clamydospores from old pea agar culture of internal fungus.

In none of the experiments above recorded was there any evidence of any tendency of a given strain of the fungus to alter its power of ascus production, nor was there evidence that external conditions exert any permanent influence upon this power.

Smith's[1] evidence that the two forms are genetically connected did not seem to the writer to be entirely conclusive. Since Smith's bulletin setting forth his conclusions treats of wilt of cotton, watermelon, and cowpea, it is not always clear what evidence he claims in the case of each separate host. Careful reading shows that all the clear evidence definitely referring to the fungus upon the cowpea that can be found in his bulletin is comprised in the two facts, t perithecia of Neocosmospora are frequently found on the plants which have been killed by the internal fungus, and that ascospores from these perithecia produced conidia which very much resemble the microconidia of the internal fungus.

---

[1] Smith, lc.

As to the first of these facts, such occurrence of perithecia is altogether too rare to have very great weight as evidence that the two fungous forms are genetically connected. Smith[1] reports the wilt disease from eleven localities, while the perithecial stage is only reported from three of these.

Atkinson reports the cotton wilt from seven localities, but does not report any perithecial stage. Since that time wilt disease caused by a Fusarium very similar or identical with *Fusarium vasinfectum* Atk. have been studied by many pathologists in diverse sections of the world; but, so far as I can find, no one except Smith and Orton has reported the ascigerous stage of Neocosmospora in connection with them. In my own experience, the Neocosmospora perithecia have been found on only three plants. In the fall of 1908 stems of a great many diseased plants were put up in test tubes. Only one of these developed perithecia. Of fifty stems and roots put up in this way in 1909 only two developed perithecia of Neocosmospora.

The perithecia of several other ascigerous fungi (notably, Melanospora) were found much more frequently on these stems than was Neocosmospora. Although hundreds of cowpea stems dead or diseased by the Fusarium wilt have been examined, I have never found the perithecial stage of Neocosmospora in the field.

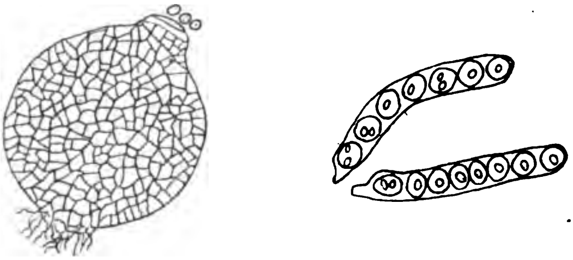


Fig. 5.—Perithecium from artificial culture on cowpea stem (perithecium x 50, asci x 280).

Smith[1] also stated further: "In the interior of these plants, both in the vessels and in parenchyma cells, there was an abundance of mycelium bearing great numbers of small colorless (white) elliptical microconidia, and at the same time, on the outside, on the salmon-colored conidia beds, enormous numbers of big lunulate, 3 to 5-septate macroconidia, the hyphæ of the fungus being readily traceable outward from the plugged or partially occupied vessels of the plant to the conidia beds on the surface." This, however, cannot be considered as evidence that the internal fungus is genetically connected with Neocosmospora; because Neocosmospora does not produce these large lunulate 3 to 5-septate spores such as are found in the external conidia beds.

COMPARATIVE CULTURES.

While making cultures such vast differences were observed between the general appearance of the internal fungus and that of the ascigerous fungus that it was thought best to make a comparative study of these two fungi to see if the differences were constant and would appear when the two fungi or strains were grown on the same media and under the same environment. The comparative cultures were made on pea agar, gelatine, rice, Irish and sweet potatoes, stems from cured cowpea hay, and stems from green cowpeas.

---

[1] Smith, lc., p. 33.

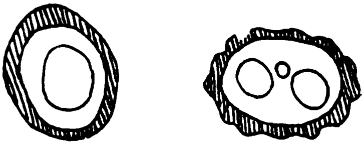


FIG. 6.—Ascospores, from Irish potato; the surface of one roughened, the other smooth (x 1050).

On Pea Agar the internal fungus made a profuse white aërial growth and large sickle-shaped 3 to 5-septate conidia, macroconidia, were produced abundantly over the surface of the medium. At the point of inoculation a rather large yellow cluster of these macroconidia was always produced. Small 1-septate or continuous conidia, microconidia, were also found in abundance.

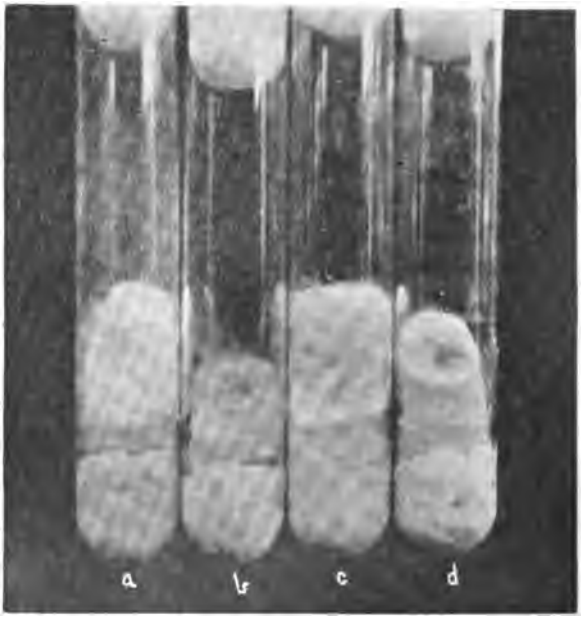


FIG. 7.—Cultures on Irish potato, 8 days after inoculation, showing difference in growth of internal fungus tubes, *a* and *c*, and ascigerous fungus tubes, *b* and *d*.

The ascigerous fungus produced an almost colorless, strict growth. No yellow spore clusters were ever produced and no 3 to 5-septate conidia were ever found. Small, hyaline, continuous or once septate conidia, very similar to the microconidia of the internal fungus, were found in abundance.

On Rice.—Probably the most striking differences shown on any medium were the different colorations produced by the internal fungus and the ascigerous fungus, particularly on rice.

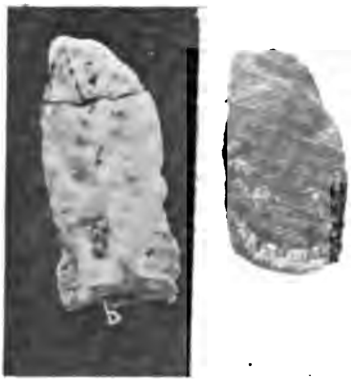


FIG. 8.—Old Irish potato cultures—*b*, internal fungus, showing sclerotia and white floccose growth; *d*, ascigerous fungus, showing numerous perithecia and scant mycelial growth.

Eight tubes of boiled rice were prepared as follows: Eight grams of rice were weighed into each tube and two cc. of water added. The tubes were then autoclaved twenty minutes at 120° C. and inoculated; four with conidia from agar cultures of the internal fungus and four with the ascigerous fungus.

FIG. 9.—Section of sclerotium showing compact mycelial structure (photo micrograph).

The internal fungus again made a much more vigorous, profuse growth. On the fourth day from inoculation a few grains in the top of tubes inoculated with the internal fungus began to turn red. The red color gradually passed down until all the rice in the tube showed some shade of red, from light rose to deep blood-red. As the cultures aged, the coloration gradually deepened until (generally, third or fourth week) it was a bluish purple. As the rice dried out and shrank away from the sides of the tubes a profuse cottony growth of mycelium was generally produced. Macroconidia were produced, but not so abundantly as on agar. Microconidia were very abundant.

In the tubes inoculated with the ascigerous fungus the coloration began as with the internal fungus; except that it was about two days later in appearing, and, instead of turning the rice red, it was changed to a dirty brown color. This did not change further, except possibly to become slightly darker brown as the rice dried out. Perithecia were produced quite freely, but they were not so red as on potato and most other media. The short uniseptate spores were quite abundant. No sickle-shaped 3-5 septate conidia were found.

On Gelatine stab cultures the internal fungus made a rapid growth, entirely covering the surface of the medium in seven days with a profuse, white, aërial growth, which changed to a light pink color at the end of two weeks. Some growth was made throughout the full length of the stab.

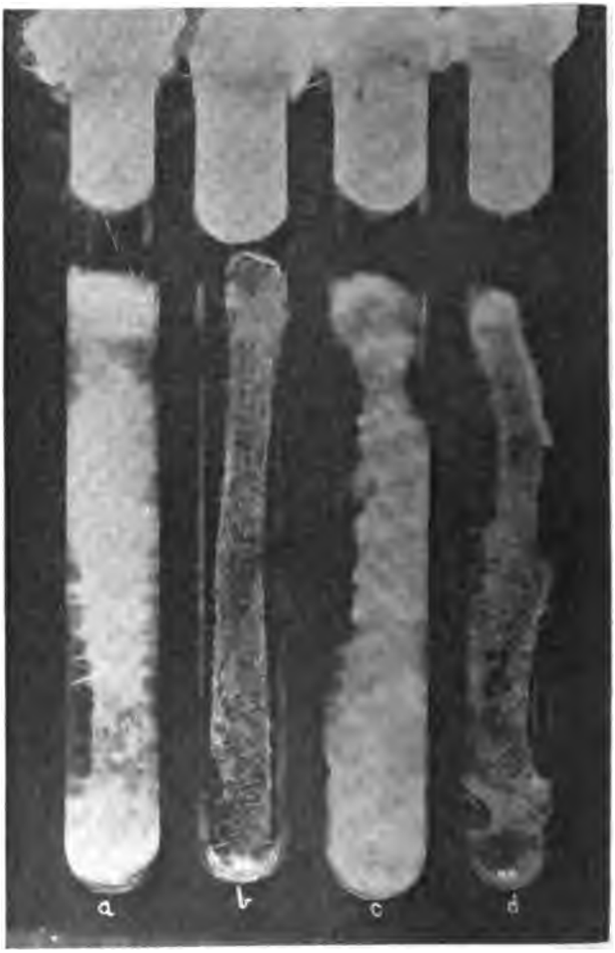


FIG. 10.—Cultures on green cowpea stems showing luxuriant white growth of internal fungus, tubes *a* and *c*, and scanty grayish growth of ascigerous fungus, tubes *b* and *d*.

The ascigerous fungus made a very slow growth. Fourteen days were required for the strict, light brownish mycelial growth to cover the surface of the medium; three weeks to cover it with a mass of blood-red perithecia. No growth was made below the surface of the gelatine.

On Potato.—The internal fungus made a very profuse white aërial growth, while the perithecial fungus made a slow growth of grayish mycelium which was only slightly aërial. This difference of growth is shown in Figs. 7 and 8, which represent two tubes of each fungus six days after inoculation. The mycelium of the internal fungus began to turn pink after it had grown seven days, and yellow clusters of spores appeared at points over the surface of the potato. What appears to be sclerotia (Figs. 8 and 9) were also produced on every potato inoculated with the internal fungus. Four days after inoculation with the ascigerous fungus onto potato a cluster of almost colorless perithecia could be seen at the point of inoculation. This cluster gradually widened and became darker until at end of two weeks the whole surface was covered with a mass of brick-red perithecia. No yellow spore clusters or sclerotial bodies were produced by the ascigerous fungus.

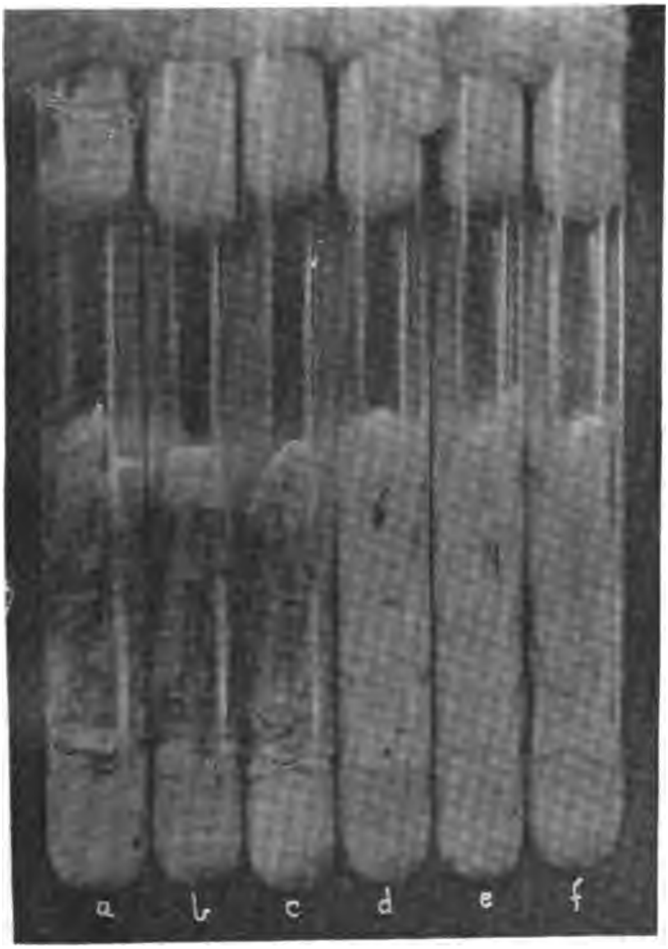


FIG. 11.—Cultures on stems of cured cowpea hay, showing luxuriant white growth of internal fungus, tubes *d*, *e* and *f*, and scanty mycelial growth and abundant perithecia of external fungus, tubes *a*, *b* and *c*.

On steamed stems of cowpea hay the growth of both fungi was very similar to that on Irish potato. The internal fungus produced many yellow spore clusters and also many small black sclerotial bodies similar to the bodies produced on the potato, except that those on the pea stems were much smaller. The perithecial fungus again produced a light grayish growth of mycelium and many bright-red perithecia, but no yellow spore clusters and no sclerotia.

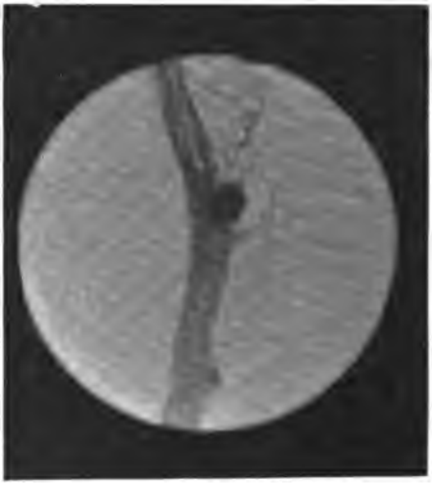


FIG. 12.—Portion of compact rhizomorphic strand of the fungus from sweet potato culture of ascigerous stage; *a* is a young perithecium (photomicrograph).

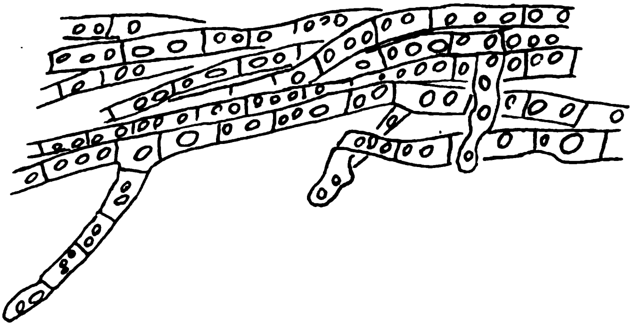


FIG. 13.—Portion of tip of rhizomorphic strand similar to Fig. 12 (x 385).

On autoclaved green cowpea stems the internal fungus rapidly made a very profuse cottony growth of mycelium (Fig. 10), tubes *a* and *c*. Comparatively few conidia of any kind were produced. Both micro- and macro-conidia were found.

The ascigerous fungus made very poor, scanty growth at first. Even two weeks after inoculation scarcely any mycelium could be seen. By the end of the third week, however, the growth of mycelium had become more prominent (Fig. 10, tubes *b* and *d*) and perithecia began to appear abundantly. The mycelium, however, was of a grayish white color and never became so floccose or profuse as that from the internal fungus. No macroconidia were found.

On Sweet Potato the growth of the internal fungus was very similar to that on Irish potato.

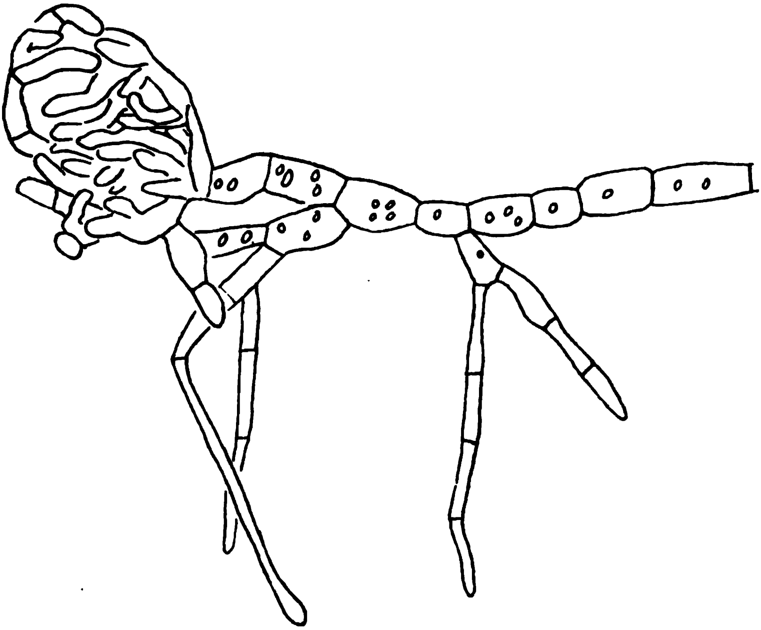
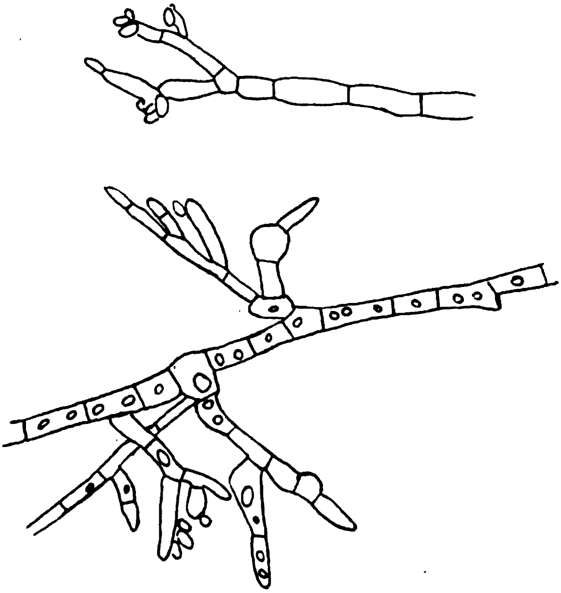


FIG. 14.—Single branch, near tip of rhizomorphic strand, bearing a young perithecium (x 385).

The ascigerous fungus, however, was very different on this medium from its growth on the Irish potato. The mycelium extended out from the surface of the potato in long, compact rhizomorphic strands (Figs. 12 and 13). Perithecia were produced in these strands in abundance, being occasionally produced on single short branches (Fig. 14). Small continuous or 1-septate conidia were also produced in abundance on short fertile hyphæ (Figs. 15 and 16). Considered alone, the habit on this medium would place the conidial stage of Neocosmospora in the Stilbaceae.

To these points of difference as brought out in my own cultures I may add that Smith failed to secure inoculations when the ascigerous fungus was used, though the parasitism of the internal fungus has never been brought to question. His words are:

"Cowpea inoculations failed with the fungus derived from ascospores of the cowpea fungus. Nine large pots were used, but all of the 170 plants remained free from disease directly attributable to the *Neocosmospora*, although under observation for many months. These were soil inoculations, and an abundance of the fungus was used."



Figs. 15 and 16.—Fertile hyphæ from rhizomorphic strand bearing microconidia (x 385).

GENERAL DISCUSSION.

It will be noted that there are several general points of difference between the two fungi under discussion, and that these are maintained in all cultures. The following are the most prominent among these differences:

First. Perithecia are continuously produced in cultures of the ascigerous form, while they were never found in cultures of the internal fungus.

Second. There is a striking difference in the appearance of the mycelial growth of the two fungi. The internal fungus on all media produced a more aërial and more floccose white mycelium than the ascigerous fungus. The growth of the internal fungus on all media was more vigorous and rapid than that of the ascigerous fungus.

Third. Large sickle-shaped 3-5 septate conidia (macroconidia) were present in all cultures of the internal fungus. They have never been found in any cultures of the ascigerous fungus.

Fourth. Clamydospores are found in all old cultures of the internal fungus. They were never found in any culture of the ascigerous fungus.

Fifth. There seems to be no tendency whatever on the part of the ascigerous fungus to produce bright colors (yellow, red, pink, or purple) in any of the substrata employed. These colors are vivid where the internal fungus is grown on starchy substrata.

These and other differences noted are made more comprehensive to the eye of the reader in the following tabulation:

ASCIGEROUS FUNGUS.	INTERNAL FUNGUS.
1. Perithecia always present.	1. Perithecia never present.
2. Growth slow.	2. Growth rapid.
3. Mycelium never pure white.	3. Mycelium on most media pure white.
4. Mycelial growth generally scanty.	4. Mycelial growth profuse on rich media.
5. Mycelium usually strict.	5. Mycelium aërial, floccose.
6. Macroconidia never found.	6. Macroconidia always found.
7. Clamydospores never found.	7. Clamydospores in all old cultures.
8. No bright color (red, yellow, pink, or purple) produced in any substrata.	8. Bright colors produced on starchy food (many shades of red and purple in rice, yellow to pink in potato, and pink in gelatine).
9. No yellow spore clusters appeared.	9. Yellow spore clusters on agar, potato, and stems of cured cowpea hay.
10. No growth below surface of gelatine.	10. Growth produced below surface of gelatine.

While these differences do not prove conclusively that the internal fungus and the *Neocosmospora* studied are not simply different strains of the same fungus, yet it would seem that these, with the other evidence presented, are sufficient to at least balance any evidence which I have been able to find to the contrary and to reopen this question, which has been regarded as closed.

The evidence for and against this question may be comprehensively summarized as follows:

Indications that the internal fungus and Neocosmospora are genetically connected.	*Indications that the internal fungus and Neocosmospora are not genetically connected.*
1. Perithecia of *Neocosmospora* are found on stem and roots of plants killed by the internal fungus.	1. Perithecia are found very rarely on such plants.
2. When grown in cultures *Neocosmospora* produces conidia very similar to the microconidia of the internal fungus.	2. Perithecia of many other ascigerous fungi are found on such stems.
	3. The perithecial stage of *Neocosmospora* has never been reported in connection with *Fusarium* wilts in other countries.
	4. *Neocosmospora* has not been observed to produce macroconidia. The internal *Fusarium* does.
	5. The internal fungus produces clamydospores. *Neocosmospora* does not.
	6. It has so far been impossible to change one fungous form into the other; *i. e.*, to stop permanently the production of peri-

thecia by *Neocosmospora* or to obtain a perithecia-producing strain from the internal fungus.

7. The two fungi are very dissimilar in general appearance, in manner of growth, and in their reactions on various substrata, as shown in detail above.

SEXUALITY OF PERITHECIA.

In view of the interesting sexual relations shown in the Mucorales[1] it is of interest to note that single hyphæ of *Neocosmospora* can produce perithecia. Therefore, if the perithecia of *Neocosmospora* are the result of any sexual act at all, it must be simply between branches arising from the same hyphæ. That they do not arise from union of the two hyphæ of separate origin is shown in conditions such as that in Fig. 14.

CONCLUSION.

In the light of the above facts, it is unreasonable to conclude that the internal fungus (*Fusarium vasinfectum* Atk.) and *Neocosmospora* are genetically related. For the present and until evidence is found to the contrary, it seems best to regard the *Neocosmospora* as simply an accidental saprophyte, having no relation to the wilt of the cowpea or to the internal fungus, *Fusarium vasinfectum*, which is probably the true cause of the wilt.

---

[1] Blakesley, A. F., Sexual Reproduction in the Mucorineae. Proc. Amer. Acad. Arts and Sci., 40, 4, 1904.

NOTE.—While the present article was in the hands of the printers my attention was called to an abstract in Annales Mycologici 8 April, 1910, p. 255-6, of an article by Dr. E. J. Butler, which upon different grounds sustains my own position regarding *Neocosmospora*. Dr. Butler worked with a wilt disease of chick-pea (*Cicer arietrium*). He found the perithecia of *Neocosmospora* on the dead vines, but considered it simply a soil parasite having no connection whatever with the *Fusarium* which caused the wilt. I have not yet seen his original article, so do not know exactly the evidence upon which his conclusion is based. B. B. H.

THE SCUPPERNONG AS A PROFITABLE CROP—METHODS OF GROWING, KEEPING, AND WINE-MAKING—USED AT ITS PLACE OF ORIGIN.

By W. C. ETHERIDGE.

A large part of North Carolina, particularly the eastern sound-bordering counties, offers an opportunity to the farmers located therein for the development of a substantial industry which may be carried to advantage along with the usual farm operations of the locality, or taken singly and more extensively.

This is the growing for commercial purposes of Scuppernong grapes, to which the section is ideally adapted in soil and climate. With such natural advantages there is wonder that this industry remains undeveloped when the only other factor wanting is a market, the lack of which may be attributed more to an absence of enterprise in seeking than to its nonexistence, for undoubtedly with some effort and advertising a market could be found for the delicious light wine that may be produced from the Scuppernong grape. There are, to be sure, a few large vineyards in the State operated on a commercial basis by several wine companies of another State; but with the small farmer, to whom the Scuppernong might be made to yield as reliable revenue as his staple crops, the industry is dormant.

These grapes are very easily grown, requiring no other care than repairs to the scaffolding or trellis every few years and an occasional pruning; in fact, there is probably no other fruit that will thrive with the minimum of care and attention which is sufficient for the Scuppernong. The writer has in mind a very old vine which has received practically no care for over a hundred years, beyond repairs to the scaffolding, and yet it fruits vigorously.

The vines are always propagated from runners which may be had from any established vine by pulling or digging up the overhanging and rooted branches. These should be set out in the fall, and may be trained either on a scaffold or trellis, the former requiring less attention, while the latter affords easier access for pruning and gathering the fruit and gives the vine more fruit-bearing surface. If a scaffolding is used, the main posts should be of fat pine, if obtainable, as these will last indefinitely, although cypress and juniper make very good ones if the part that is to be buried is given a coating of tar. The running poles are best if of large cypress, or juniper saplings, 3 to 5 inches in diameter, stripped of their bark; yet any sort of pole or rail may be used for this purpose, as it may easily be replaced when rotten. If trellising is preferred, convenience may again be regarded in the selection of posts, as on account of their small size it is not difficult to replace them when needed.

When the vines are trained on a scaffold, pruning presents the only difficulty that occurs in their keeping, and this is obviated by the lack of actual necessity for it. By pulling the dead wood out of the vine once in several years it can be kept in fairly good condition. A trellised vine would, however, require more attentive pruning.

For making wine only ripe and perfectly sound grapes should be used. When fully ripe they are shaken into large sheets of burlap, or cloth, spread underneath the vine, the shaking being easily accomplished by jarring the vine with a pole crotched at one end by which a hold is obtained on the vine. Such trash from the vine, leaves and broken bits of stems or twigs, as may have fallen into the sheet is carefully picked out and the grapes are ready for the press.

The process is very simple, being only a flat, shallow trough about 8 feet long, 3½ feet wide at one end, tapering down to about 18 inches at the other, and having fixed at about 30 inches from the wider end a wooden roller 6 or 8 inches in diameter. This roller is covered spirally with strips of leather which give it a better catch on the grapes and make it less liable to smash the seed than if its surface were bare. To either or both ends is fitted a crank for turning. When in use, the trough is fixed between four posts at a convenient height for pouring in the grapes and is slightly inclined for the flow of the juice. The grapes are poured into the trough behind the roller, and it is slowly turned over them, crushing out the juice, which is received into a pail or tub placed beneath the lower end of the trough and is then strained into stands usually made by sawing a good oaken barrel through the middle. The juice is afterward filtered through some material that will catch the smaller rags of pulp and broken bits of seed which have escaped the strainer. A filter commonly used in the eastern part of the State is made of small pieces of sea-shells wrapped or mixed with clean, bright broom-grass and placed in a large funnel. This is very effective in clearing the juice.

After filtering, the juice is transferred to barrels, where it may be sweetened at once or after fermentation, this depending upon the quality of wine desired. If the sweetening is done before the juice ferments the wine retains much of the mild, natural flavor of the ripe fruit, but does not have the body, or "tang," that results if fermentation is first allowed. The amount of sugar to be used in sweetening is between two and three pounds per gallon of juice, and varies with the time the wine is to be kept: if it is intended for use within a year or two, less sugar is required than if the wine is to be aged: and less is needed if the sweetening is done before than after fermentation. After the juice is in the barrels the bungs are left out until all the fermentative gases have escaped, and are then driven tightly in.

Converting the fruit into wine is easily the most profitable disposal that can be made of it, provided a market can be found. A bushel of grapes will yield, even with the present crude methods of pressing, three gallons of wine, exclusive of the sugar added in sweetening. This should sell for at least $2 per gallon, making a gross return of $6 per bushel for the grapes. The cost of making the wine is small, as the method is a simple and easy one, requiring little skill and no apparatus that may not be provided at home. The only material entering into the process that need call for a direct expenditure is the sugar used in sweetening, and even this is used at a profit, as it increases the volume of the wine in about the same proportion as its own volume, the value of the extra quality of wine produced exceeding the cost of the sugar.

II.—STUDIES IN SOIL BACTERIOLOGY[1]—AMMONIFICATION IN SOILS AND IN SOLUTIONS.

By F. L. STEVENS and W. A. WITHERS, assisted by J. C. TEMPLE and W. A. SYME.

In an earlier article[2] we called attention to the fact that inoculation of soils into solutions gives no adequate criterion of the nitrifying powers of soils, owing to the fact that some nitrifying soils fail entirely to nitrify in solutions, and that when in other cases nitrification occurs to some extent in each medium, the amount of nitrification in solutions is not commensurate with the amount of nitrification by the same soils, as soils. The question naturally arises whether a similar condition does not exist regarding the process of ammonification.

Ammonification for the present purpose may be defined as the conversion of organic nitrogen into ammonical nitrogen. It is probably the most important of all the nitrogen transformations, and accurate knowledge of the conditions which favor it is of permanent importance.

The studies of ammonification which have been made—and they are very numerous and important—have been conducted by isolating organisms and studying the chemical transformations induced by such pure cultures in solutions of artificial composition, or by throwing, in various ways, complexes of species in the form of small amounts of soils, or of suspensions derived from soils, into solutions for the purpose of study.

In view of the importance of the subject and in view of the doubts cast upon the validity of results arrived at by present methods of studying ammonification, a series of experiments was undertaken to ascertain whether reliable conclusions regarding the ammonifying power of a soil can be had by study of its effects when inoculated into solutions.

The bacteriological methods used were similar to those described in the earlier paper mentioned above, with exception as to the form of nitrogen used,[3] and may be so understood unless special description is given.

CHEMICAL METHODS.

To 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that already present in the soil, to make 1,200 cubic centimeters, and the mixture shaken for one hour. After settling somewhat, the solution was filtered through a Pasteur-Chamberland filter. An aliquot part was taken. Nitrogen in the form of ammonia was liberated by magnesium oxide, caught in a standard acid solution and titrated with a standard alkali solution.

When the amount of ammonia was very small it was nesselrized instead of being titrated.

The amounts are expressed in terms of nitrogen.

---

[1] Published in Centbl. Bakt. (etc.), 2 Abt., 23 (1909), Nos. 21-25, pp. 776-785.

[2] Stevens and Withers, studies in soil bacteriology—Nitrification in soils and in solutions. (Thirty-first Rpt. N. C. Expt. Sta., pp. 40-63) and Centbl. Bakt. (etc.), 2 Abt., 23 (1909), Nos. 10-13, pp. 355-373.

[3] Stevens and Withers, lc.

EXPERIMENTS.

Experiment 62 was designed to test the relative rapidity of ammonification in soils as compared with solutions. Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were on December 12, 1907, placed in 500 cc. Erlenmeyer flasks, 400 cc. of tap water was added to each and the whole autoclaved at 115° for 15 minutes, then inoculated with 1 cc. of soil suspension from experiment 32[3] and allowed to stand nine days.

Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were also mixed with 400 grams of soil 1866. The mixture was autoclaved as above and inoculated with 10 cc. of soil suspension from experiment 32 in such a way as to be about two-thirds saturated after inoculation, and then allowed to stand twelve days. Analyses at the end of the period gave results indicated in Table I.

TABLE I.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Conditions.						Results.	
Sample Number.	Time of Incubation—Days.	Medium—Kind.	Inoculum.		Form of Initial Nitrogen.	Ammoniacal Nitrogen Recovered.	
			Kind.	Quantity in cc.		Per Cent.	Mgs. per 100 cc. Solution.
1938	9	Water	Soil	1	Peptone	72.5[4]	43.5
1939	9	Water	Suspension from Experiment 32	1	Asparagin	100.0	60.0
1940	9	Water	Suspension from Experiment 32	1	C. S. M.[5]	36.5	21.9
1955	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Peptone	26.6	106.4
1956	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Asparagin	32.9	135.6
1957	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	C. S. M.	23.1	92.4

It is seen here that though the soil culture received ten times as large an inoculum, *i. e.*, ten times as many bacteria, and stood three days longer, the ammonia produced in it from peptone was 36 per cent of that produced in solution, 33 per cent in the case of asparagin, and 65 per cent in the case of cotton-seed meal.

While the experiment does not admit of definite conclusions, because of the lack of parallelism in duration of the experiment and amount of inoculum, it certainly indicates very strongly that there is a great difference in the ammonifying power of this soil under the two conditions, *i. e.*, (1) when inoculated into solution, (2) when inoculated into soil itself.

---

[3] Stevens and Withers, lc.

[4] The ammonia originally present was determined and found to be of negligible quantity.

[5] C. S. M. signifies cotton-seed meal.

Experiment 63 was begun on December 7, 1907, precisely as experiment 62, except that the inoculum was greenhouse soil 1866.

The results are shown in Table II.

TABLE II.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Conditions.					Results.	
					Ammoniacal Nitrogen Recovered.	
Sample Number.	Time of Incubation—Days.	Medium—Kind.	Inoculum—Quantity in Grams.	Form of Initial Nitrogen.	Per Cent.	Milligrams per 100 cc. Solution.
1941	9	Water	1	Peptone	79.1[a]	47.5
1942	9	Water	1	Asparagin	78.1	46.9
1943	9	Water	1	Cotton-seed meal	39.8	23.9
1958	12	Soil 1866	10	Peptone	22.4	86.9
1959	12	Soil 1866	10	Asparagin	28.7	114.8
1960	12	Soil 1866	10	Cotton-seed meal	17.5	70.0

[a] Original ammonia was of negligible amount.

Conditions similar to those found in the previous experiment are noted. Based upon the per cent of ammonia found, peptone and asparagin are ammonified much more vigorously in solutions than in soil cultures; cotton-seed meal likewise, but not with so marked a difference, there being 28 per cent, 36 per cent, 44 per cent, as much ammonia produced in soil as in solution with peptone, asparagin, cotton-seed meal respectively.

Experiment 88. One hundred and twenty milligrams of nitrogen as cotton-seed meal were weighed into 300 cc. Erlenmeyer flasks, 200 cc. of tap water added, and the whole sterilized.

One hundred and twenty milligrams of nitrogen as cotton-seed meal were also mixed with 200 grams of each soil to be tested, flasked, and sterilized.

One hundred grams of the soil to be tested were well shaken with 200 cc. of water and 1 cc. of the suspension was added to each flask of the solution. One cc. of the suspension was also added to 20 cc. of sterile water, mixed, and this diluted suspension was poured into the sterile soils in the flasks and thoroughly mixed. Soils 1667, 1867, 1783, 1784, 1931, and 2069 were tested in this manner, thereby bringing into 200 grams of solution the same number of organisms and the same species of organisms as were mixed with 200 grams of the soil culture. This arrangement also provided that the organisms in soil media were in soils of the same quality as the soils from which these organisms were derived (identically the same soil, except for sterilization). The cultures were incubated seven days and then analyzed.

The results are given in Table III.

Table III.—Comparing of Six Different Soils Regarding Ammonification in Soil and in Solution.

Conditions.			Results.	
Sample Number.	Medium—Kind.	Inoculum—Suspension of Soil.	Ammoniacal Nitrogen Recovered.	
			Per Cent.	Milligrams per 100 cc. Solution.
2152	Solution	1667	18.2[7]	10.9
2153	Soil		9.1	18.2
2154	Solution	1867	34.3	20.6
2155	Soil		18.9	37.8
2156	Solution	1783	23.1	13.9
2157	Soil		14.7	29.4
2158	Solution	1784	37.1	22.3
2159	Soil		22.4	44.8
2160	Solution	1931	24.5	14.7
2161	Soil		18.9	37.8
2162	Solution	2069	24.5	14.7
2163	Soil		30.8	61.6

[7] Original ammonia was of negligible amount.

Here, again, considering the per cent of ammonia produced, there is a great difference in the intensity of ammonification in soils and in solutions. In five of the six samples of soil tested, ammonification was again greater in the solution than in the soil cultures, while in one instance ammonification was greater in the soil culture.

Not only is there a difference in rapidity and absolute quantity of ammonification, but the rank of the soils as ammonifiers is different according to whether their ammonifying powers are measured in soils or in solutions.

Compared in Soil Cultures, their Rank as Ammonifiers is:	Soil Number.	Compared in Solution their Rank is:
1	2069	3
2	1784	1
3	1867	2
4	1931	3
5	1783	5
6	1667	6

Experiment 82. To test relative ammonifying powers of various pure cultures in soil and in solution.

The tests above recited were made with soils, composites of bacterial species. It was deemed advisable to ascertain how far the conclusions indicated by these tests hold true when pure cultures of species are employed. To this end fifteen pure cultures of ammonifying organisms were obtained from the most promising sources by plating from soils, cow manure, horse manure, and from two labeled cultures from the laboratory stock, and all of these pure cultures were inoculated into broth.

On March 16, 1908, 120 milligrams of nitrogen as cotton-seed meal were weighed into each of sixteen 300-cc. Erlenmeyer flasks, and 200 cc. of tap water added. An equal amount of cotton-seed meal was mixed with 200 grams of soil in each of the sixteen flasks of the same size. All were autoclaved for one hour. Both soil and liquid media were inoculated with 1 cc. of broth culture. To inoculate the soil flasks, tubes with 20 cc. of sterile water were first inoculated with 1 cc. of the broth culture and this dilution poured upon the soil and mixed with it. Ammonia was determined at the end of the fourth day. The results are given in Table IV.

TABLE IV.—COMPARING AMMONIFICATION OF PURE CULTURES IN SOIL AND IN SOLUTION.

Conditions.			Results.			
			Ammoniacal Nitrogen Recovered.			
Sample Number.	Medium—Kind.	Inoculum—Kind.	Per Cent.	Difference in Favor of Soil.	Mgs. per 100 cc. Solution.	Difference in Favor of Soil.
2077	Sterile soil 1867	Organism 1	12.6	—11.4	25.2	10.8
2078	Water		24.0		14.4	
2079	Sterile soil 1867	Organism 2	7.0	— 5.1	14.0	6.7
2080	Water		12.1		7.3	
2081	Sterile soil 1867	B. subtilis	25.2	14.2	50.4	43.8
2082	Water		11.0		6.6	
2083	Sterile soil 1867	Organism 4	1.4	1.4	2.8	2.8
2084	Water		0.0		0.0	
2085	Sterile soil 1867	Organism 5	37.2	17.6	74.4	62.6
2086	Water		19.6		11.8	
2087	Sterile soil 1867	Organism 6	23.8	5.1	47.6	36.4
2088	Water		18.7		11.2	
2089	Sterile soil 1867	B. mycoides	2.8	— 3.0	5.6	2.1
2090	Water		5.8		3.5	
2091	Sterile soil 1867	Organism 8	22.4	6.5	44.8	35.3
2092	Water		15.9		9.5	
2093	Sterile soil 1867	Organism 9	18.2	2.6	36.4	27.0
2094	Water		15.6		9.4	
2095	Sterile soil 1867	Organism 10	23.8	— 4.9	47.6	30.4
2096	Water		28.7		17.2	
2097	Sterile soil 1867	Organism 11	34.3	5.8	68.6	51.5
2098	Water		28.5		17.1	
2099	Sterile soil 1867	Organism 12	3.5	0.0	7.0	4.9
2100	Water		3.5		2.1	
2101	Sterile soil 1867	Organism 13	32.9	13.3	65.8	54.0
2102	Water		19.6		11.8	
2103	Sterile soil 1867	Organism 14	21.7	2.8	43.4	32.1
2104	Water		18.9		11.3	
2105	Sterile soil 1867	Organism 15	9.8	6.8	19.6	17.8
2106	Water		3.0		1.8	
2107	Sterile soil 1867	Soil susp. 1867	27.3	10.5	54.6	44.5
2108	Water		16.8		10.1	

Here, basing on per cent of ammonia, ammonification was greater in soils than in solutions in the large majority of cases. In only four instances was ammonification greater in solution than in soils. Basing upon amount converted per cc. of solution, the ammonification was greater in the soil in every instance. Basing upon per cent converted, the rank in ammonifying power is as follows:

Rank Tested in Soils.	Soil Number.	Rank Tested in Solution.	Source of Organism.
1	2085	4	Horse manure.
2	2097	2	Horse manure.
3	2101	4	Soil.
4	2107	8	Cow manure.
5	2081	12	Soil.
6	2087	7	Cow manure.
6	2095	1	Manure.
8	2091	9	Soil.
9	2103	6	Soil.
10	2093	10	Soil.
11	2077	3	B.—subtilis culture.
12	2105	15	Soil.
13	2079	11	B.—mycoides culture.
14	2099	14	Horse manure.
15	2089	13	Cow manure.
16	2083	16	Cow manure.

Five species hold the same rank in soil and solution; two have changed one rank; two, two ranks; four, three ranks; one, five; one, six; and one, seven ranks; some assuming a higher rank in soils, others higher in solutions.

It is seen from the tabulation that not only is the absolute ammonifying power different in the two media, but also that the rank of the organisms as ammonifiers is greatly altered by the mode of test.[1]

Experiment 105. On May 25, 1908, to further test the same point, whether tests made in solutions are fair criteria by which to judge either the absolute or relative ammonifying power of soils, experiments 105, 200, and 201 were made. In these experiments 120 milligrams nitrogen as cotton-seed meal was used, with 200 grams medium and 1 cc. inoculum.

In these experiments the cultures were all made in duplicate and with checks. Four soils were used, and with each the ammonifying power was tested in three ways, as follows:

1. By inoculation of a suspension into a sterile mixture of cotton-seed meal and water (*i. e.,* solution condition).
2. By inoculation of a suspension into sterile soils.
3. By adding the nitrogenous material directly to the live soil.

The results are given in Table V and summarized in Table VI.

---

[1] While the analyses of all samples were not completed on the same day, the analyses of all cultures inoculated with the same soil were made at the same time. Therefore, while the actual rank of these cultures as ammonifiers is not given here, the general conclusion drawn is legitimate.

TABLE V.—SHOWING AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Conditions.				Results.			
				Ammoniacal Nitrogen Recovered.			
Sample Number	Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2285	10	Water	Suspension of 1784	29.00	26.86	17.4	16.1
2286	10	Water	Suspension of 1784	29.40		17.6	
Average				29.20		17.5	
2287	10	Water		2.34		1.4	
2288	10	Sterile soil	Suspension of 1784	21.01	19.21	84.0	76.8
2289	10	Sterile soil	Suspension of 1784	22.40		89.6	
Average				21.31		85.2	
2290	10	Sterile soil		2.10		8.4	
2291	10	Live soil 1784		22.40	21.35	89.6	85.4
2292	10	Live soil 1784		23.10		92.4	
Average				22.75		91.0	
2293	10	Sterile soil 1784		1.40		5.6	
2294	10	Water	Suspension of 1667	26.20	24.31	15.7	14.6
2295	10	Water	Suspension of 1667	27.10		16.3	
Average				26.65		16.0	
2287	10	Water		2.34		1.4	
2296	10	Sterile soil 1784	Suspension of 1667	9.80	11.20	39.2	44.8
2297	10	Sterile soil 1784	Suspension of 1667	12.60		50.4	
Average				11.20		44.8	
2298	10	Sterile soil 1784		0.00		0.0	
2299	10	Live soil 1667		0.70	9.10	2.8	36.4
2300	10	Live soil 1667		17.50		70.0	
Average				9.10		36.4	
2301	10	Sterile soil 1667		0.00		0.0	
2372	4	C. S. M. + H_2O	Suspension 2069	11.20	8.98		5.4
2373	4	C. S. M. + H_2O	Suspension 2069	9.10		6.1	
Average				10.15		0.7	
2374	4	C. S. M. + H_2O		1.17			
2375	4	Sterile 1867	Suspension 2069	23.81	18.56		37.1
2376	4	Sterile 1867	Suspension 2069	23.11		46.9	
Average				23.46		9.8	
2377	4	Sterile 1867		4.90			
2378	7	Live 2069		32.21	27.66		63.9
2379	7	Live 2069		30.11		72.0	
Average				31.16		8.1	
2380	7	Sterile 2069		3.50			
2390	7	C.,S. M. + H_2O	Suspension 2069	14.24	18.21		10.9
2391	7	C. S. M. + H_2O	Suspension 2069	23.57		11.3	
Average				18.91		0.4	
2392	7	C. S. M. + H_2O		0.70			
2393	7	Sterile 1867	Suspension 2069	28.01	23.46		46.9
2394	7	Sterile 1867	Suspension 2069	24.51		52.5	
Average				26.26		5.6	
2395	7	Sterile 1867		2.80			
2396	7	Live 2069		32.91	31.86		73.6
2397	7	Live 2069		37.81		81.7	
Average				35.36		8.1	
2380	4	Sterile 2069		3.50			
2363	4	C. S. M. + water	Soil suspension 1931	6.77	7.24		4.3
2364	4	C. S. M. + water	Soil suspension 1931	9.10		4.8	
Average				7.94		0.5	
2365	4	C. S. M. + water		0.70			
2366	4	Sterile soil 1867	Soil suspension 1931	25.21	17.51		35.0
2367	4	Sterile soil 1867	Soil suspension 1931	23.81		45.0	
Average				24.51		10.0	
2368	4	Sterile soil 1867		7.00			

TABLE V—*Continued.*

Sample Number.	CONDITIONS.			RESULTS.			
	Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Ammoniacal Nitrogen Recovered.			
				Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2369	4	Live soil 1931		24.51			
2370	4	Live soil 1931		26.60			
Average				25.56	23.46	54.7	50.2
2371	4	Sterile soil 1931		2.10		4.5	
2381	7	C. S. M. + water	Soil suspension 1931	4.43			
2382	7	C. S. M. + water	Soil suspension 1931	13.07			
Average				8.75	8.05	5.3	4.8
2383	7	C. S. M. + water		0.70		0.5	
2384	7	Sterile soil 1867	Soil suspension 1931	28.70			
2385	7	Sterile soil 1867	Soil suspension 1931	28.70			
Average				28.70	23.10	57.4	46.2
2386	7	Sterile soil 1867		5.60		11.2	
2387	7	Live soil 1931		24.50			
2388	7	Live soil 1931		22.41			
Average				23.46	22.06	50.2	47.2
2389	7	Sterile soil 1931		1.40		3.0	

TABLE VI.—SUMMARY OF ALL RESULTS GIVEN IN TABLE V.

Medium.	Soil Inoculum.	Days.	Net Nitrogen as Ammonia. Per Cent.	Days.	Net Nitrogen as Ammonia. Per Cent.
C. S. M. and H_2O	1931	4	7.24	7	8.05
Sterile soil 1867	1931	4	17.51	7	23.10
Live 1931		4	23.46	7	22.06
C. S. M. and H_2O	2069	4	8.98	7	18.21
Sterile 1867	2069	4	18.56	7	23.46
Live 2069		4	27.66		31.86
C. S. M. and H_2O	1784	10	26.86		
Sterile 1784	1784	10	19.21		
Live 1784		10	21.35		
C. S. M. and H_2O	1667	10	24.32		
Sterile 1784	1667	10	11.20		
Live 1867			9.10		

It is seen here that at the end of four days soils 1931 and 2069 ammonified most vigorously in natural condition, next in sterile soil plus suspension, and least in the watery suspension; Nos. 1784 and 1667 most in watery suspension. It appears, then, that some soils will give a maximum test of ammonifying power in the liquid medium, others in the soil medium; that the test made in the liquid is not a fair criterion of ammonifying power. Though the differences are not so great as is the case with the phenomenon of nitrification.

they are sufficient to change the rank of soils in ammonifying power—as, for example, in the above case where soil 1931 ammonified more than three times as rapidly in soil as in solution, as did also soil 2069; while soil 1784 ammonified a trifle better in solution than in soil. It is apparent that a proper comparison of the actual field ammonifying power of these three soils could not be had by comparing their ammonifying power in solutions. It is to be noted, also, that in the original data from which these conclusions are drawn determinations were made in duplicate with control cultures, and for the most part with excellent agreement between duplicates.

Experiment 209. On August 20, 1908, an experiment similar to the preceding was also made with pure cultures of several laboratory species and of three "wild" forms, Nos. 5, 7, and 11, isolated from various sources.

To inoculate, 1 cc. of a 48-hour old broth culture was added to 20 cc. of sterile water and poured into the soil flask or into the liquid culture, all in strictly parallel manner. The results are presented in Table VII. The initial nitrogen present in the form of cotton-seed meal was 120 milligrams; incubation was for seven days.

As with the composite inoculations of the last experiment, some species are seen to ammonify more vigorously in solution, other species in soils.

Organism No. 5 produced less than 7 per cent as much ammonia in solution as in soil; *B. megatherium*, 32 per cent; *B. mycoides*, 19 per cent. While organism No. 7 produced only 42 per cent as much ammonia in soil as in solution, organism No. 11 gave 46 per cent.

Ranking the organisms according to their ammonifying power in solution, we have No. 7, No. 11, *subtilis*, *megatherium*, *mycoides*, No. 5; in soil, *subtilis*, *megatherium*, No. 11, No. 7, *mycoides*, No. 5.

Thus it is seen that neither the absolute nor the relative ammonifying power of these organisms for soil can be ascertained by testing them in solutions.

SUMMARY AND CONCLUSIONS.

1. Some bacterial soil complexes ammonify faster in solutions.
2. Some bacterial soil complexes ammonify faster in soils.
3. Some pure cultures of organisms ammonify faster in soils, others faster in solutions.
4. The rank of soils, bacterial soil complexes, or of pure cultures is different as measured in soils or in solutions.

The general conclusion stands out clearly, as it did regarding nitrification, that neither for soils nor pure cultures of organisms can the ammonifying power be adequately determined by testing in solutions; that not even the relative ammonifying power of two soils or two organisms can be determined with certainty by the method of testing in solutions. While there is not so great a discrepancy between results by the solution and the soil method with regard to ammonification as obtains regarding nitrification, still the difference is sufficient to necessitate using soil as the medium in which to test ammonifying powers in cases where any degree of accuracy is desired and to check all determinations by soil cultures.

TABLE VII.—TEST OF PURE CULTURES FOR AMMONIFICATION IN SOIL AND IN SOLUTION.

CONDITIONS.				RESULTS.							
				Ammoniacal Nitrogen Recovered.							
Sample Number.	Medium—Kind.	Amount in cc.	Inoculum—Kind.	Per Cent.		Excess in Favor of Soil.	Excess in Favor of Solution.	Milligrams Per cc. Solution.		Excess in Favor of Soil.	Excess in Favor of Solution.
				Found.	Average.			Found.	Average.		
2437	Sterile 1867	200	B. subtilis	16.84	16.14	3.91	-------	33.7	32.3	7.8	-------
2438		200		15.44				30.9			
2439	Water	60	B. subtilis	11.41	12.23			22.8	24.5		
2440		60		13.05				26.1			
2441	Sterile 1867	200	B. mycoides	8.42	7.72	6.22	-------	16.8	15.4	12.4	-------
2442		200		7.02				14.0			
2443	Water	60	B. mycoides	0.52	1.50			1.0	3.0		
2444		60		2.48				5.0			
2445	Sterile 1867	200	B. megatherium	14.38	14.21	9.54	-------	28.8	28.4	19.0	-------
2446		200		4.04				28.1			
2447	Water	60	B. megatherium	4.21	4.68			8.4	9.4		
2448		60		5.14				10.3			
2449	Sterile 1867	200	Organism No. 5	8.03	7.26	6.77	-------	16.1	14.5	13.5	-------
2450		200		6.49				13.3			
2451	Water	60	Organism No. 5	0.37	0.49			0.7	1.0		
2452		60		0.61				1.2			
2453	Sterile 1867	200	Organism No. 7	11.16	10.85	-------	14.87	22.3	21.7	-------	29.7
2454		200		10.53				21.1			
2455	Water	60	Organism No. 7	25.27	25.72			-------	51.4		
2456		60		26.16				-------			
2457	Sterile 1867	200	Organism No. 11	12.63	11.56	-------	13.15	25.3	23.1	-------	26.3
2458		200		10.49				21.0			
2459	Water	60	Organism No. 11	24.28	24.71			48.6	40.4		
2460		60		25.13				50.3			

III.—STUDIES IN SOIL BACTERIOLOGY—CONCERNING METHODS FOR DETERMINATION OF NITRIFYING AND AMMONIFYING POWERS OF SOILS.[1]

By F. L. STEVENS AND W. A. WITHERS.[2]

Nitrate nitrogen is generally believed to be the most readily available and most valuable form of nitrogen for plants. If this view be true, even in part, means of measuring the ability of various soils to produce nitrate nitrogen, to nitrify, are desirable, since on the nitrifying power of the soil would depend to some extent, possibly to a large extent, its productivity. To determine nitrifying power; to recognize deficiencies in nitrifying power; to ascertain the cause of such deficiencies when they exist and to find means of correcting them, all require quantitative studies of this factor of soil fertility. To make quantitative determinations of nitrifying power that shall be of broad utility and general value, methods which may be regarded as standard must be devised and their trustworthiness recognized. The biological equilibrium in soils is one of utmost instability, and variations in methods are likely to lead to great discrepancies in results.[3] These facts have been constantly forced upon us during the investigations of the past few years and have led us to the consideration of the question of uniform methods in this regard, the results of which we herewith present.

NITRIFYING INDICES.

Three conditions to be recognized in considering the nitrifying ability of a soil are:

1. The nitrifying organisms present.
2. The physical and chemical fitness of the soil for the proper functioning of these organisms.
3. The nitrifying efficiency of the soil and the organisms existing in it.

NITRIFICATION INOCULATING POWER (N I P).

The first index may be called the Nitrification Inoculating Power, which may be abbreviated as N I P. It recognizes only the factor of the live organisms present, taking no account of the fitness or unfitness of the soil for their activity. It does not regard bacterial species, but merely the complex present in the soil at the time it is tested.

Theoretically, the N I P may be high in a soil in which, owing to adverse chemical or physical conditions, no nitrification really occurs. Theoretically, nitrifying bacteria may be present in goodly numbers in a soil possessing physical and chemical conditions favorable to rapid nitrification, yet no nitrate appear, owing to the presence of other species of bacteria or of substances which either inhibit the action of the nitrifiers or destroy the nitrate which they produce, so that nitrate does not appear as a final product. N I P considers only the efficiency of the organisms present to give nitrate as a final product under circumstances favorable to their growth.

---

[1] Read at the North Carolina Academy of Science, May 1, 1909, Durham, N. C. Published in Cent. Bakt. 25, 1909, 64.

[2] Assisted by J. C. Temple, W. A. Syme, J. K. Plummer and P. L. Gainey.

[3] Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. (N. C. Expt. Sta. Rpt. 1907-1908, pp. 40-63.)

NITRIFYING CAPACITY (N C).

The second index, fitness of the soil as regards factors other than its content of living things, *i. e.*, its capacity to support nitrification, provided proper organisms be present, may be designated as its Nitrifying Capacity, abbreviated as N C. N C regards only the nonliving factors. Theoretically, a soil may be of high N C, but still fail to nitrify owing to lack of proper organisms, *i. e.*, to lack of proper N I P. Theoretically, a soil may be of low N C, yet show high N I P. N C will on final analysis be found to depend upon physical conditions and chemical composition, including water content.

NITRIFYING EFFICIENCY (N E).

The third index may be designated as the nitrifying efficiency of the soil, abbreviated N E, which regards the efficiency of the soil as a whole to produce nitrates as a final product. N E may be low owing to lack of N I P or to lack of N C, or both. N E will be high if there be high N I P associated with high N C.

Proper determination of N E will show whether a given soil is in normal vigorous nitrifying condition; if such is not the case, determination of N C and N I P will show whether it is the bacterial or nonbacterial factors which are at fault, and may lead the way to correction of existing defects.

CONDITIONS FOR DETERMINING THESE INDICES.

To make each of these indices of the greatest value the determination must be made as nearly as possible under the conditions that normally obtain in the field. Field conditions are highly variable from season to season, even from hour to hour, and may never be twice exactly alike. They can therefore be only approximated.

Since the soil temperature is extremely variable, sometimes above, sometimes below the optimum for nitrification, it seems best to employ the optimum temperature as standard.

Since the water relation is of dominating importance,[1] the amount of water in the soil cultures should imitate the natural condition of the soil that is to be tested. If this soil be one that is normally saturated or under water, swampy, the cultures should provide these conditions. It is difficult to determine the degree of saturation which best imitates the condition of a normal well-drained field. During and shortly after rain it is saturated. It rapidly dries, and until another rain occurs is considerably below saturation. Since, however, the greater part of the nitrification that does occur must occur during a period approximating the water content, optimum for nitrification, it seems best to use, as nearly as is practicable, this degree of saturation for all soils, other than soils normally saturated as mentioned above.

---

[1] Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. Centbl. Bakt. II ab. XXIII, pp. 355–373.

PRELIMINARY EXPERIMENTS.

Preliminary experiments were made to ascertain several facts of importance in deciding upon methods, such as the optimum water relation, the effects of different modes of aëration, etc., upon nitrification when soils constitute the medium. The results of these experiments are as follows:

Experiment 2. To determine thermal death point of nitrifying organisms in soil. Forty grams of soil 1867, which had shown nitrifying power, with nitrogen added as asparagin, were put in each of six large test tubes. A tube of this soil was kept in the water bath, which had a temperature of 35°, for ten minutes after the temperature of the soil in a tube under similar conditions had reached 35°. Other tubes were in the same way exposed to temperature of 40°, 45°, 50°, 55°, and 60°.

Six sterile flasks, each of 400 gs. of soil 1867, containing 240 mgs. of nitrogen as asparagin, were then inoculated with the 20 gs. of soil, one flask from each of the tubes, and allowed to stand four weeks, when the nitrate present was determined.

The nitrification resulting was as follows:

Soil heated to 35° contained 27.36 per cent of N as nitrates.
Soil heated to 40° contained 30.28 per cent of N as nitrates.
Soil heated to 45° contained 35.24 per cent of N as nitrates.
Soil heated to 50° contained 38.16 per cent of N as nitrates.
Soil heated to 55° contained 24.28 per cent of N as nitrates.
Soil heated to 60° contained 00.00[1] per cent of N as nitrates.
Check, not inoculated, 000[1] per cent of N as nitrates.
Check, not inoculated, 000[1] per cent of N as nitrates.

It is seen that the thermal death point lay between 55° and 60°, a conclusion in accord with previously reported results.[2]

Experiment 76. To determine the influence of access of air. Two sets of cultures were made and incubated for four weeks beginning February 27, 1908, one with flasks cotton plugged in the usual manner, one with flasks hermetically sealed. Medium was live soil 1867 and 240 mgs. of nitrogen and cottonseed meal.

The results are given in Table I.

---

[1] Nitrites and nitrates were tested for with diphenylamine solution. In case there was a coloration after one or two minutes, the amount of nitrites and nitrates was determined by the Teimann-Schulze method. If only a faint coloration appeared, which disappeared upon shaking, a trace was reported; and if no coloration at all appeared, the amount of nitrites and nitrates was recorded as zero. The test was made as follows (Treadwell-Hall Anal. Chem., 1906, Vol. 1, page 340):

"The reagent is prepared by dissolving 0.5 gms. of diphenylamine in 100 cc. of pure concentrated sulphuric acid and adding 20 cc. of water. A few cubic centimeters of the diphenylamine solution are placed in a test tube and carefully covered with the solution to be tested for nitric acid. If the latter is present, there is formed at the zone of contact between the two liquids a ring of beautiful blue color."

Treadwell states that "if one cc. of an acid (concentrated sulphuric S. and W.) which contains only one-twentieth milligram of nitrogen in a liter is used, the reaction will cause a noticeable coloration."

This test is less delicate in water solutions than in concentrated sulphuric acid. Wherever the amount of nitrites or nitrates is recorded in this article as zero small amounts may have been present and escaped detection.

[2] Lafar Technischen Mykologie, III.

TABLE I—EXPERIMENT 76—EFFECT OF SEALING FLASK UPON NITRIFICATION.

Sample Number.	Condition of Aeration.	Per Cent of Initial Nitrogen Recovered as—		
		Ammonia.	Nitrite.	Nitrate.
2115	Sealed	35.71	0.00[1]	0.00[1]
2116	Sealed	23.11	0.00[1]	0.00[1]
2117	Not sealed	0.70	Trace	35.39
2118	Not sealed	0.00	Trace	25.99

The entire absence of nitrification in the sealed flasks quite precludes the use of such flasks in determining nitrifying indices, though for the purpose of avoiding evaporation sealed flasks would be desirable.

To ascertain whether the degree of compactness of the soil in the flask is of influence upon nitrification, cultures were set up with 400 gs. of live soil 1867+ 240 mgs. of nitrogen as cotton-seed meal or ammonium sulphate. The soil in two flasks was tightly compacted; in two others loosely sifted in; in two others the soil was removed and sifted twice weekly to give more complete aëration. Two other cultures were made in shallow dishes having an area each of 400 sq. cm. to give still more free aëration, but were covered with bell jars to prevent drying. Set up December 15, 1908. Analyses were made at the end of six weeks.

The results appear in Table II.

TABLE II—EXPERIMENT 60—TO ASCERTAIN THE EFFECT UPON NITRIFICATION OF DEGREE OF COMPACTNESS OF SOIL.

Number.	CONDITION OF EXPERIMENT.		RESULTS OF EXPERIMENT.
	Condition of Soil.	Form of Nitrogen.	Per Cent of Nitrogen Found as Nitrate.
1991	Compact	Cotton-seed meal	62.6
1992	Compact	Ammonium sulphate	76.1
1993	Loose	Cotton-seed meal	63.6
1994	Loose	Ammonium sulphate	70.5
1995	Sifted	Cotton-seed meal	74.2
1996	Sifted	Ammonium sulphate	73.0
1997	In open dish	Cotton-seed meal	26.0
1998	In open dish	Ammonium sulphate	16.3

The first time this experiment was tried the sealed flasks broke from internal pressure; the second time, escape of gases was provided for by a water seal.

It is seen that with neither of these forms of nitrogen is the effect of the compactness of the soil, as shown in the first six flasks, of much influence upon nitrification under the conditions of the experiment. The low nitrification in the shallow dishes may have been caused by molds which developed to some extent in these cultures.

Experiment 210. September 7, 1908. To determine whether the optimum degree of saturation for pure cultures is the optimum for the bacterial complex of soil 1867. Four-week cultures were made in sterile soil 1867+240 mgs. of nitrogen as ammonium sulphate, with different degrees of saturation, and inoculations were made with suspension from soil 1867 in some instances, with pure cultures of nitrifying organisms in other cases. The pure cultures consisted of a vigorous nitrite former and a vigorous nitrate former, isolated by the Stevens-Temple Silicate Jelly Plate.[1]

They were pure in the sense employed by Winogradsky in that they did not render buillon cloudy. They gave the following nitrogen changes:

TABLE III.

CULTURE OF	GAVE—
Nitrite organism in ammonium solution	Nitrite.
Nitrate organisms in ammonium solution	No nitrate and no nitrite.
Nitrate organisms in nitrite solution	Formed nitrate.
Nitrite organisms in nitrate solution	No denitrification.
Nitrate organisms in nitrate solution	No denitrification.

The results of Experiment 210 are given in table below.

TABLE IV—EXPERIMENT 210, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1867.

	CONDITIONS.			RESULTS.		
Number.	Degree of	Inoculum—Kind.	Amount.	Percentage of Initial Nitrogen Recovered as—		
				Ammonia.	Nitrite.	Nitrate.
2606	One-third	Nitrite + nitrate organisms	1 cc. each	45.51	0.15	12.53
2607	One-third	Nitrite + nitrate organisms	1 cc. each	46.35	0.38	11.06
Average				45.93	0.26	11.78
2608	Two-thirds	Nitrite + nitrate organisms	1 cc. each	38.51	1.87	13.16
2609	Two-thirds	Nitrite + nitrate organisms	1 cc. each	39.21	1.87	12.50
Average				38.81	1.87	12.83
2610	Complete	Nitrite + nitrate organisms	1 cc. each	44.11	0.07	0.00
2611	Complete	Nitrite + nitrate organisms	1 cc. each	44.74	trace	0.00
Average				44.47	0.04	0.00
2612	One-third	Susp. soil 1867	10 cc.	51.81	0.13	20.98
2613	One-third	Susp. soil 1867	10 cc.	54.61	0.12	17.54
Average				53.21	0.13	19.26
2614	Two-thirds	Susp. soil 1867	10 cc.	56.02	0.10	12.84
2615	Two-thirds	Susp. soil 1867	10 cc.	55.45	0.08	12.62
Average				55.73	0.09	12.73
2616	Complete	Susp. soil 1867	10 cc.	63.02	trace	0.00
2617	Complete	Susp. soil 1867	10 cc.	broken	trace	trace
Average				63.02	trace	0.00

---

[1] Stevens and Temple, "A convenient mode of preparing silicate jelly." (Centbl. Bakt., p. II, XXI, 1908, p. 84.)

It is seen that the optimum for the pure culture differs from that of the soil 1867 and that no appreciable nitrification occurred under conditions of saturation with either inoculum.

Experiment 240. To determine the optimum degree of saturation of soil 1931 and the effects of slight variation in water content. 400 gs. of sterile soil 1931+240 mgs. of nitrogen as ammonium sulphate were inoculated with 10 cc. of suspension of soil 1867. Flasks were set up in duplicate carrying water to give 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 per cent of saturation. The results are presented in Table V.[1]

TABLE V—EXPERIMENT NO. 240, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1931.

	CONDITIONS.		RESULTS.		
Number.	Water Added.		Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3128	48	25	0.45	2.68	3.13
3129	48	25	0.52	4.18	4.70
Average	48	25	0.49	3.43	3.92
3130	--	--	trace	1.00	1.00
Net	--	--	0.49	3.43	2.92
3131	58	30	0.75	5.51	6.26
3132	58	30	0.45	8.32	8.77
Average	58	30	0.60	6.92	7.52
3130	--	--	trace	1.00	1.00
Net	--	--	0.60	5.92	6.52
3134	67	35	1.50	8.53	10.03
3135	67	35	0.60	12.44	13.04
Average	67	35	1.05	10.49	11.54
3130	--	--	trace	1.00	1.00
Net	--	--	1.05	9.49	10.54
3136	77	40	1.00	18.40	19.40
3137	77	40	0.75	18.04	18.79
Average	77	40	0.88	18.22	19.10
3130	--	--	trace	1.00	1.00
Net	--	--	0.88	17.22	18.10
3138	86	45	1.35	23.39	24.74
3139	86	45	1.35	26.21	27.56
Average	86	45	1.35	24.80	26.15
3130	--	--	trace	1.00	1.00
Net	--	--	1.35	23.80	25.15
3140	96	50	1.20	27.62	28.82
3141	96	50	0.45	27.74	28.19
Average	96	50	0.83	27.68	28.52
3130	--	--	trace	1.00	1.00
Net	--	--	0.83	26.68	27.52
3142	106	55	0.45	28.99	29.44
3243	106	55	0.45	29.62	30.07
Average	106	55	0.45	29.31	29.76
3130	---	--	trace	1.00	1.00
Net	---	--	0.45	28.31	28.76
3144	115	60	1.20	36.28	37.58
3145	115	60	1.45	38.64	40.09
Average	115	60	1.33	37.51	38.84
3130	---	--	trace	1.00	1.00
Net	---	--	1.33	41.51	37.84

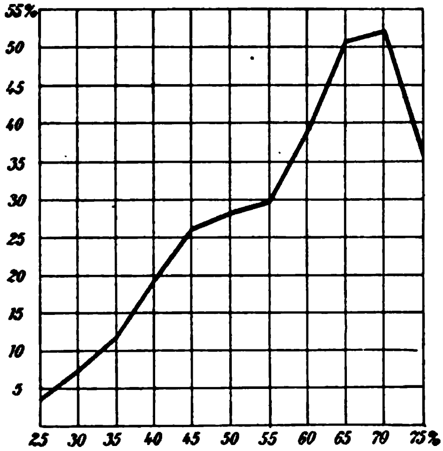
---

[1] Slight corrections have been made in this table since its original publication in the *Centralblatt fur Bakteriologie*, etc.

TABLE V—*Continued.*

Number.	Conditions.		Results.		
	Water Added.		Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3146	125	65	0.30	49.81	50.11
3147	125	65	0.30	51.06	51.36
Average	125	65	0.30	50.44	50.74
3130	---	--	trace	1.00	1.00
Net	---	--	0.30	49.44	49.74
3148	134	70	0.30	52.94	53.24
3149	134	70	trace	51.36	51.36
Average	134	70	0.15	52.15	52.30
3130	---	--	trace	1.00	1.00
Net	---	--	0.15	51.15	51.30
3150	144	75	0.30	36.66	36.96
3151	144	75	0.38	34.71	35.09
Average	144	75	0.34	35.69	36.03
3130	---	--	trace	1.00	1.00
Net	---	--	0.34	34.69	35.03

These facts are presented graphically in the following curve. It is seen that there is a gradual increase in nitrification with the increase in water content up to 70 per cent of saturation, and that beyond that point nitrification falls off rapidly with increase in water content.



Curve of nitrification at different degree of soil saturation. 1 cm. on the ordinate=5 per cent of initial nitrogen converted into nitrite or nitrate nitrogen. 1 cm. on the abscissa=5 per cent of saturation.

Experiment 211. September 10, 1908. To determine whether the degree of saturation that is optimum for one soil is optimum for others. Three sterile soils of very different saturation capacity were taken; 400 gms. of each were mixed with 240 mgs. of nitrogen as ammonium sulphate, inoculated with 10 cc. of suspension of soil 1867, and incubated four weeks.

The results are given in Table VI.

TABLE VI—EXPERIMENT 211—TO ASCERTAIN WHETHER THE DEGREE OF SATURATION THAT IS OPTIMUM FOR NITRIFICATION IN ONE SOIL IS OPTIMUM FOR OTHER SOILS.

CONDITION OF EXPERIMENT 211.				RESULTS OF ANALYSIS.		
Number.	Medium—Soil.	Water Added.		Percentage of Initial Nitrogen as—		
		CC.	Degree of Saturation.	Ammonia.	Nitrite.	Nitrate.
2619	1549	30	One-third	41.31	0.43	13.57
2620	1549	30	One-third	39.91	0.83	14.10
Average	1549	30	One-third	40.61	0.63	13.83
2621	1549	60	Two-thirds	24.51	2.25	24.29
2622	1549	60	Two-thirds	24.09	3.37	26.08
Average	1549	60	Two-thirds	24.30	2.81	25.18
2623	1549	100	Three-thirds	50.41	0.10	0.00
2624	1549	100	Three-thirds	52.79	0.10	0.00
Average	1549	100	Three-thirds	51.60	0.10	0.00
2625	1783	48	One-third	25.21	0.90	23.49
2626	1783	48	One-third	28.01	1.80	21.94
Average	1783	48	One-third	26.61	1.35	22.21
2627	1783	100	Two-thirds	16.80	0.25	23.82
2628	1783	100	Two-thirds	22.41	0.37	22.86
Average	1783	100	Two-thirds	19.60	0.31	23.34
2629	1783	144	Three-thirds	63.02	0.10	0.00
2630	1783	144	Three-thirds	57.42	0.12	0.00
Average	1783	144	Three-thirds	60.22	0.11	0.00
2631	1931	60	One-third	35.01	0.23	44.79
2632	1931	60	One-third	26.01	0.23	46.67
Average	1931	60	One-third	30.51	0.23	45.73
2633	1931	120	Two-thirds			
2634	1931	120	Two-thirds	8.40	trace	82.00
Average	1931	120	Two-thirds			
2635	1931	180	Three-thirds	43.41	0.10	trace
2636	1931	180	Three-thirds	45.51	0.10	trace
Average	1931	180	Three-thirds	44.46	0.10	trace

In this case each soil did better in soil culture of two-thirds saturation than in either one-third or complete saturation, though the degree of effect of this factor varies with the different soils, soil 1783 giving results about equal at one-third and two-thirds saturation, while the two other soils show nearly 100 per cent better results at two-thirds than at one-third saturation.

TABLE VII—EXPERIMENT 202, SHOWING EFFECT OF SOIL, *i. e.*, N C. UPON NITRIFICATION.

CONDITIONS.		RESULTS.		
Number.	Medium.	Percentage of Initial Nitrogen Recovered as—		
		Ammonia.	Nitrites.	Nitrates.
2398–9	Sterile 1867	15.41	trace	17.75
2400–1	Sterile 2250	31.86	trace	0.00
2402–3	Sterile 2404	63.72	trace	0.00

From the last three experiments, considered together, we must conclude that for different soils or different inoculums there are different optima of saturation.

Experiment 202. To show the effect upon nitrification of soils with different N C, set up July 13, 1908. Incubated four weeks, mixed 400 gms. of soil with 240 mgs. nitrogen as ammonium sulphate. Inoculum 10cc. of suspension of soil 1867. The results are shown in Table VII.

It is here seen that the same inoculum failed to induce nitrification in two soils, though it brought about marked nitrification in the other soils, showing clearly the effect of the soil itself upon nitrification, *i. e.*, of the necessity of recognition of what we here term nitrifying capacity (N C).

Experiment 231. To determine whether with different inoculums different rank is given to soils as to their N C. Period four weeks, medium sterile soil 400 gs., nitrogen 240 mgs. as ammonium sulphate.

TABLE VIII—EXPERIMENT 231, SHOWING EFFECT UPON N C OF DIFFERENT INOCULUMS.

Number.	CONDITIONS OF EXPERIMENT. Began Experiment.	Medium Sterile Soil Number.	Inoculum Suspension of Soil.	RESULTS. Per Cent of Initial Nitrogen Recovered as Nitrites and Nitrates.	Rank in N C.
2949–'51	12– 3–08	1549	No. 1867	0.00	
2952–'4	12– 3–08	1783	No. 1867	0.00	
2955–'7	12– 3–08	1931	No. 1867	9.09	1
2958–'60	12– 3–08	2069	No. 1867	0.00	
2961–'3	12– 7–08	1549	Filter bed	5.10m	2
2964–'6	12– 7–08	1783	Filter bed	3.89m	3
2967–'9	12– 7–08	1931	Filter bed	12.85	1
2971–'2	12– 7–08	2069	Filter bed	0.60	4
2993–'5	12–14–08	1549	N. J. soil	0.00	
2996–'8	12–14–08	1783	N. J. soil	0.00	
2999–3001	12–14–08	1931	N. J. soil	0.00	
3002–'4	12–14–08	2069	N. J. soil	0.00	
3022–'4	12–21–08	1549	Wis. soil	0.00	
3025–'7	12–21–08	1783	Wis. soil	4.36m	2
3028–'30	12–21–08	1931	Wis. soil	6.58p	1
3031–'3	12–21–08	2069	Wis. soil	0.00	

m Signifies that the duplicate samples agreed well.
p Signifies that the duplicate samples did not agree well.

It is here seen that though soil 1931 gave the highest N C with each inoculum used, there is variation in N C as determined by the use of different inoculums, since soils 1549 and 1783 failed to nitrify when inoculated with suspension of 1867, though one of them nitrified when inoculated with the Wisconsin suspension and both when inoculated with the filter-bed suspension.

RESULTS OF PRELIMINARY TESTS OF N E AND OF N I P DETERMINED IN SOILS AND N I P DETERMINED IN SOLUTIONS.

THE SOILS TESTED.

The soil from Geneva was sent by H. A. Harding with the statement that it came from a field "which has been in grass for many years, having been plowed up and borne one crop of corn. The land is of fairly stiff clay and of course well supplied with organic matter."

The soil from New Jersey, supplied by Dr. Lipman, was a red shale "which had been neglected for many years, but which has received thorough cultivation for the last three years." The other was from "an area which has been receiving application of 10-20 tons of manure annually for more than fifteen years."

The soil from District of Columbia, supplied by Dr. Kellerman, was a very rich, black, sandy loam which was said to be of good nitrifying power. The soil from Michigan, supplied by Prof. W. S. Sayer, was a "black soil from a low plat, but well drained. It was used for celery last year and for potatoes this year after a heavy coat of barnyard manure."

The soil from Wisconsin is described by A. R. Whitson of the Wisconsin Experiment Station as follows: "From a field of clay loam soil of glacial drift origin in a limestone region. The subsoil is sandy at a depth of three to five feet. The surface drainage is fairly poor, underdrainage is good. The field has been in alfalfa perhaps three-fourths of the time the past twelve years. During that time it has had top dressings of manure at about fifteen to twenty loads to the acre every three years. It is Plat No. 8 as described in Prof. F. H. King's reports on field work in the annual reports of this Station, from the fourteenth to the twentieth. It has grown two or three other crops of corn and oats."

Two of these soils supplied by Dr. Stephen DeM. Gage were from the sewage filter beds Nos. 1 and 9 of Lawrence, Mass., "which were yielding a highly nitrified effluent."

The Georgia soil, supplied by Mr. J. C. Temple, was from a rich, sandy loam garden.

All of these soils were sent in response to a request for soils most promising as nitrifiers.

Experiments 218, 219, 221. Determination of N E and N I P.

These experiments were conducted after the manner already reported and are sufficiently explained by the accompanying summary.

TABLE IX—SUMMARY OF RESULTS OF EXPERIMENTS 218, 219, 221, SHOWING RELATION N E, N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solution.	Rank
1	Filter No. 1	32.4	5	12.5	4	5.0	4
2	Filter No. 9	56.0	4	25.8	2	10.7	1
3	Michigan	85.2	1	12.2	5	2.9	6
4	Wisconsin	77.4	2	15.5	3	6.0	3
5	New Jersey, H	4.6	6	54.0	1	4.4	5
6	New Jersey Red Shale	70.5	3	4.7	6	7.0	2
7	D. C.			8.1m		4.5	

Some of the above tests were made without checks and some without duplicates, and are therefore subject to slight though probably insignificant error.

TABLE IXa—EXPERIMENT 230, SHOWING RELATION N E, N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solution.	Rank.
1	Filter No. 9	37.6	7	49.6	2	12.9	1
2	New Jersey, H	38.3	6	0.00	5	0.00	6
3	Michigan	90.31	1	8.45	1	9.79	2
4	Wisconsin	67.34	3	4.56	3	1.62	3
5	New Jersey Red Shale	62.33	5	trace	4	trace	5
6	Geneva	65.78	4	0.00	6	1.62	3
7	Georgia No. 1	80.82	2			0.00	6

[1] These determinations were made in duplicate and with checks. Duplicates agreed well.

It is seen in the above summaries that not only does the ordinary solution test fail to give the true rank of the soils in nitrifying power (seen most clearly in the case of the Georgia soil), but that the soil test also fails to do so, indicating clearly that N C plays an important part in determining the N E, and that all that can be had by a soil or a solution test is merely an indication of the bacterial conditions, not a true measure of nitrifying power of the soil in its natural condition.

METHODS FOR STANDARD ANALYSIS.

In the light of these preliminary experiments and of results previously reported, we have formulated the following rules for determining the N E, N I P, and N C of soils. The results of some hundreds of determinations by these methods we shall present in the annual report of the Experiment Station at a later date.

DETERMINATION OF THE N E OF SOILS.

Screen the soil to be tested through a wire sieve, of 3-4 mm. mesh (opening), to remove stones, sticks and coarser matter and to make the soil of good condition to manipulate; then determine its saturation capacity. To do this, 50 grams of soil, present saturation of which is known, are placed on a porcelain plate in a carbon filter and a measured quantity of water, a little more than necessary to saturate the soil, is added, and the effluent is poured upon the soil and allowed to drain through again. This operation is repeated twice to insure complete saturation. The amount of water taken up by the soil is determined by measuring the final effluent and subtracting from the measured quantity originally employed. Allowance is made for water already in the soil.

Weigh live soil equal to 400 gs. of dry soil[1] into a 500 cc. Erlenmeyer flask; add 240 mgs. of nitrogen as sterilized ammonium sulphate solution, with proper precaution against the introduction of germs extraneous to the soil (*i. e.*, using sterile sieves, containers, ladles, washing the hands with nearly surgical care, etc.); add sterile water sufficient, together with that already in the soil, to make it closely approximate two-thirds saturation; plug loosely with cotton; incubate at 30 to 35 degrees for four weeks.

---

[1] Dried two hours at 110°.

Set up in duplicate and with two control flasks, *i. e.*, 400 gs. of the same soil in the same conditions, but without added nitrogen. Make up water loss weekly in all flasks. Determine the amount of nitrite and nitrate present in each flask at the end of the incubation period and report in terms of the element nitrogen.[2]

Subtract the average of the nitrite and nitrate nitrogen found in the two control flasks to give the *net nitrite and nitrate nitrogen* produced by organisms in the soil in question.

Express the N E as a coefficient equal to the per cent of the original 240 mgs. of added nitrogen that is represented by the net nitrite and nitrate nitrogen found.

When determining the N E for soils normally saturated or immersed, test the soils saturated instead of two-thirds saturated.

DISCUSSION OF N E METHOD.

To strictly reflect field conditions, humidity should be that of the field. Field conditions are, however, variable and such nitrification as does occur takes place mainly at moisture nearly the optimum. We therefore adopt two-thirds saturation as a standard condition for normally drained agricultural soils, and of course a condition of complete saturation for all soils that are normally saturated. Since soils vary in their optimum moisture relation, it would be still better to use the optimum for each separate soil studied. This is, however, manifestly impossible except in case of exhaustive research upon special soils.

The temperature suggested is near the optimum for most nitrifying bacterial complexes and is adopted for substantially the reasons leading to the adoption of the optimum saturation.

The time, four weeks, nearly one-third of a crop-growing season, is ample to give easily measured results in cases of soils in good nitrifying condition. Very poor nitrifiers would give different records with longer time; but this would retard work greatly, probably without affecting conclusions materially.

Aëration is probably better in these test conditions than in the field, but probably not so different as to materially affect results. (See experiment 76.)

That some nitrate is formed in the soils that is not recovered in analysis is certain. This is the chief objection to the use of soils as a medium; but in view of the complete inadequacy of solutions as a medium, there is no escape from the dilemma, and soils must be used.

Experiment 315. To determine the power of water to extract added nitrates from the soil. For this purpose three samples of soil were taken, viz.: Nos. 1931, a sandy loam, 3553, a red clay, and 3705, a soil rich in organic matter which had been used for horticultural pot experiments. These soils yielded to water respectively 2.38, 0.92, and 3.72 mgs. nitrogen per 400 gs. of soil. Separate portions of 400 gs. of soil were taken, sodium nitrate was added in amounts which corresponded to various percentages of 240 mgs. nitrogen. The samples were shaken two hours with the usual amount of water and nitrates were determined in the water extracts. These amounts are expressed as follows. Deductions were made of the amounts extracted from the natural soils.

---

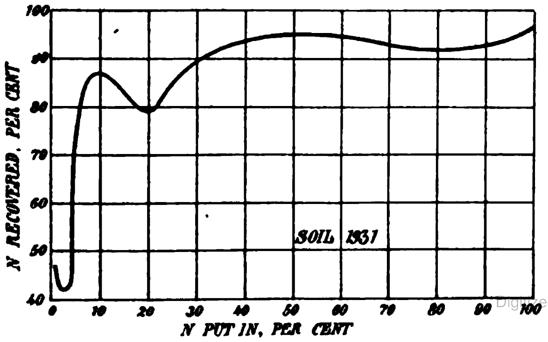
[2] Stevens and Withers. I—Studies in Soil Bacteriology. Centbl. Bakt. Abt. II, Bd. 23, 1909, p. 355.

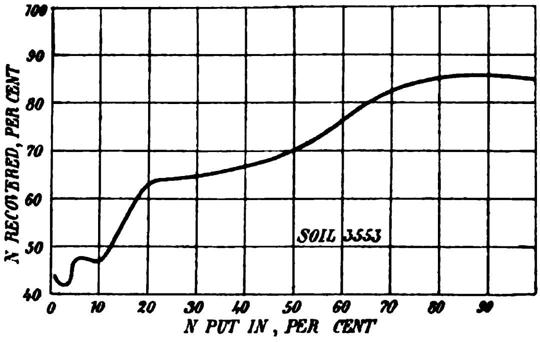
TABLE X—EXPERIMENT 315, TO DETERMINE THE ABILITY OF WATER TO EXTRACT ADDED NITRATES FROM THE SOIL.

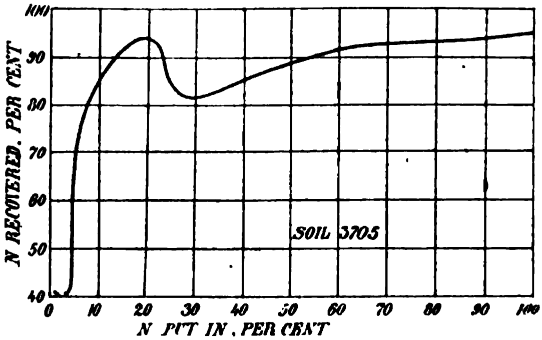
Determined.	Nitrogen Added, Percentage of 240 Mgs.	Percentage of Nitrogen Recovered from Soil Number—.		
		1931.	3553.	3705.
1	1.00	41.66	44.16	40.80
2	1.00	53.10	44.16	40.80
Average	1.00	47.38	44.16	40.80
1	3.00	41.66	42.20	40.00
2	3.00	41.66	42.20	40.00
Average	3.00	41.66	42.20	40.00
1	5.00	69.09	47.33	68.00
2	5.00	69.09	47.33	68.00
Average	5.00	69.09	47.33	68.00
1	10.00	87.70	47.00	87.70
2	10.00	84.50	47.00	81.40
Average	10.00	86.60	47.00	84.55
1	15.00	83.45	54.21	91.93
2	15.00	83.45	55.52	91.93
Average	15.00	83.45	54.87	91.93
1	20.00	79.85	62.65	93.95
2	20.00	78.30	64.20	93.95
Average	20.00	79.08	63.38	93.95
1	25.00	85.20	65.56	84.44
2	25.00	83.92	62.64	83.92
Average	25.00	84.56	64.10	84.18
1	50.00	96.46	68.90	90.20
2	50.00	93.96	70.16	89.58
Average	50.00	95.21	69.53	89.39
1	75.00	92.47	83.92	92.88
2	75.00	91.63	83.10	93.29
Average	75.00	92.05	83.51	93.09
1	100.00	97.09	85.19	95.21
2	100.00	97.40	84.56	94.59
Average	100.00	97.25	84.88	94.90

These tables show the recovery of only about 40 per cent nitrates when small quantities were added and more than twice this amount when large quantities were added. These results show that figures given elsewhere in this paper are not absolute; but as the percentage recovered increases fairly regularly, the incomplete recovery does not interfere with the conclusions, which have been drawn.

These facts are represented graphically in the following diagrams, which were drawn by L. L. Vaughan:







TO DETERMINE N I P OF SOILS.

Make a bacterial suspension from the soil to be tested, taking 100 gs. of soil to 200 gs. of sterile distilled water, shaking three minutes, sedimenting for five minutes, using the supernatant fluid. All work to be done aseptically. As a medium use the equivalent of 400 gs. of dry standard soil, sterilized, two-thirds saturated, with 240 mgs. of nitrogen added as ammonium sulphate. After inoculation with 75 cc. of the bacterial suspension from the soil to be tested, culture in Erlenmeyer flasks as for the determination of N E.

Do in duplicate and determine the nitrite and nitrate nitrogen present at end of four weeks. From the average of the two flasks subtract nitrite and nitrate nitrogen equal to that in the culture at the beginning, if any, to secure the *net nitrite* and *nitrate nitrogen produced.*

Express N I P as a coefficient equal to the per cent of original nitrogen changed to nitrite and nitrate nitrogen under these standard conditions in standard time. When determining N I P for soils normally saturated, use saturated cultures.

DISCUSSION OF N I P METHOD.

An artificial soil of high N C, which might be universally standard, is desired, but our attempts to construct such an artificial medium have failed utterly.

We recognize that with the use of a different standard soil somewhat different results would be had, but are convinced that the results had by the method here outlined approach the truth more nearly than earlier methods advocated and employed and give a near approximation to the truth. No one medium can reveal the whole truth.

The standard used by us is our soil 1931, which may be described as follows:

TABLE XI—STANDARD SOIL 1931—CLASSIFICATION, CECIL SANDY LOAM.[1]

Gravel over 2 mm. diameter, 2.72 per cent. Mechanical analysis of the fine particles shows the following:

	Diameter mm.	Per Cent.	
1	2–1	3.74	Fine gravel.
2	1–.5	9.91	Coarse sand.
3	.5–.25	9.42	Medium sand.
4	.25–.1	32.55	Fine sand.
5	.1–.05	13.52	Very fine sand.
6	.05–.005	22.07	Silt.
7	.005–.0	8.84	Clay.
Total		100.05	

A chemical analysis showed the soil to contain:

Moisture	7.03	per cent.
Humus	2.61	per cent.
Nitrogen total	0.082	per cent.
Nitrogen as nitrites	0.000	per cent.
Nitrogen as nitrates	0.0006	per cent.
Alkalinity in terms of $CaCO_3$	0.0074	per cent.
Phosphoric acid	Faint trace.	

TO DETERMINE N C OF SOILS.

The soil to be tested shall be prepared as for the determination of N E, then sterilized, inoculated, and subsequently treated as for the determination of the N I P; using the same inoculum at the same time in parallel cultures in standard soil. All cultures to be done in duplicate with controls.

The N C is expressed as a coefficient equal to the coefficient obtained by the soil to be tested, divided by the coefficient obtained by the standard soil.

If it were possible to maintain a standard inoculum, the N C could be directly determined, but means of maintaining such an inoculum have not yet been devised.

We recognize here that the use of a different inoculum would lead to somewhat different results, and that tests with no one inoculum can reveal the whole truth.

---

[1] The classification and mechanical analysis were made by G. M. MacNider, Assistant Chemist, N. C. Department of Agriculture.

STANDARD METHOD REGARDING AMMONIFICATION.

For the same reason set forth regarding nitrification, we believe that the ends of soil bacteriology will be furthered by the adoption of similar indices regarding the soil factor of ammonification. We therefore propose the terms Ammonifying Efficiency (A E), Ammonifying Inoculating Power (A I P) and Ammonifying Capacity (A C), to be determined in the following ways:

To Determine A E.

The sample to be prepared and tested as for N E, with the exception that 200 gs. of soil be used and that nitrogen 120 mgs. be added as cotton-seed meal instead of as ammonium sulphate; incubation to be for seven days: analysis to be for ammonia.[1]

To Determine A I P.

The sample to be prepared and tested as for N I P, except that nitrogen be added as cotton-seed meal medium 200 gs. inoculum 25 cc. and that incubation be for seven days and analysis for ammonia.

To Determine A C.

The sample to be prepared and tested as for N C medium 200 gs., the inoculum to be 1 cc. of a pure culture of B.. *Subtilis* twenty-four hours old in standard beef bouillon at incubator temperature, which culture was inoculated with one oese from another culture. This inoculum to be frequently standardized against standard soil and corrections made for any change from its original ammonifying power.

---

[1] For methods see Stevens and Withers, II—Studies in Soil Bacteriology. Centbl. Bakt. ab. II, Bd. 23, 1909, p. 776.

[PRESS BULLETIN, NO. 16, SEPTEMBER 1, 1908.]

SELECTING SEED CORN FOR LARGER YIELDS.

BY C. B. WILLIAMS, DIRECTOR.

The practice of selecting seed corn from the barn late in the spring costs the farmers of North Carolina, in decreased yields of shelled corn, an amount equal to more than five million dollars annually. Just so long as this method is followed, just so long will the corn growers of the State lack this amount of producing what they might with the same treatment under identical conditions were they to use better methods in the selection of their seed corn. The proper place to select seed for planting purposes next year is in the field this fall. One day spent in the field in selecting seed corn properly will pay better in increased yields than most any labor performed during the entire year. There are many ways in which this work might be done satisfactorily, the exact method depending upon local conditions and practices. Economy of performance of the operation is always to be looked after, but not at a sacrifice of efficiency. Where corn is gathered from stalks in the field in the usual way, a good method for the corn grower to use is to sling a cotton-picking bag over the shoulder or take a basket in the hand and go through and make the selections from the field of corn which he has that is a little above the average in productivity. Take two rows at a time and select seed from those stalks which have two well-developed ears per stalk, remembering that in the selection of seed one should select from the stalks that will yield the largest amount of shelled corn per stalk. The reason why it is advised selecting from two-eared stalks is because in testing and studying varieties of corn during the past eight years on the Experiment Station farm, and elsewhere, it has been found that the best yielders of shelled corn per stalk, and hence per acre, were those that averaged near two ears per stalk. Take both of the ears if they are good ones, and reject both if they are not. Do not give much detailed attention to the shape of the ears and grains during field selection, but reserve this for some rainy or snowy day during the winter and have the young boys around to help, as there is no form of farm work that will interest them more or lead them to take a deeper interest in the work of the farm. One reason why so many boys leave the farm is because they are not taught that there is something more in farming than the mere drudgery connected with it. When going through the field selecting these ears it might be well to have the boys along too, if they are old enough to appreciate the value and importance of what is being done. A cart or wagon might be at one end of the rows and when you get there each time empty the basket or bag. Enough corn should be gathered in this way so that when the more careful selection is made during the winter at the barn, having in mind the best shape of ears and kernels, enough will be left for planting, after throwing out the ears of poor shape and those having kernels not up to the proper type it is wished to use for planting. Select from the field three to five times as much corn as it is expected to be needed, so that a very rigid selection of the ears may be made during some winter day. Make selections from stalks that not only bear two well-developed ears, but from those that have a good leaf development and large root system. Select ears that are borne at a uniform and convenient height, for such ears are more easily and cheaply gathered, they ripen more uniformly, and are less liable not to have the embryo grains fertilized, as the tasselling of all stalks will be practically at the same date and the pollen from all will be given off at about the same time. The ears should be held not upright, but in a rather drooping position, as such ears are less liable to rot, as they will shed the rain rather than admit it into the ears, as they frequently do when held in an upright position: especially is this so if the husks (shucks) do not cover the tips of the ears completely. Also, it is well to discard all ears that have the tips poorly covered with husks, even if all the other characteristics are up to requirements. When, during the winter, the corn thus gathered is gotten out for more careful selection, choose those ears of cylindrical shape and those which possess deep wedge-shaped and large-germed grains which completely and deeply cover the cobs and which are arranged in parallel rows. Select heavy, well-matured ears that have medium-sized cobs with kernels that are heavy in weight and medium rough in indentation, and which have the butts and tips fairly well filled out. Keep the seed stored in a dry place until planting time.

If you have not selected your seed corn before from the field in the way indicated above, try it this fall. You may be a little doubtful of the value of this extra effort, but give it a fair trial and we feel sure that you will never go back to the old and less profitable method of selecting seed corn from the barn.

[PRESS BULLETIN, NO. 18, FEBRUARY 15, 1908.]

THE APPLE BITTER ROT.

BY F. L. STEVENS, BIOLOGIST.

Occurrence in North Carolina.—This disease occurs in very destructive form throughout the Piedmont and eastern sections of the State, though it is possibly less destructive further west. In a recent trip through the middle section of the State the writer saw dozens of orchards ruined by this rot which, but for the presence of it, would have yielded largely. In many of the orchards visited the trees were in fine condition, showing suitability of soil and climate, and they bore an abundance of fruit, but closer examination showed that the ground under the trees was completely covered with rotten apples and that the apples still on the trees had numerous specks of soft, brown rot. In many villages and towns all apples offered for sale in stores were affected with this rot.

The facts as stated above show the very destructive prevalence of this disease in this State.

This rot has been known in destructive form in the United States since 1867. It is estimated to have done $1,500,000 of damage in four counties in Illinois in 1900. In the Middle States the losses are estimated to be from one-half to three-fourths of the entire crop. The President of the National Apple Shippers' Association estimated the damage in the United States in 1900 at $10,000,000.

Description of the Bitter Rot.—There are many different types of apple rot—some are hard, some soft, some wet, some dry, some of one color and some another, etc. The bitter rot of the apple, sometimes called the ripe rot, is a soft, wet, yellow rot, occurring usually as circular spots on the fruit. These spots, of which there may be from one to twenty or more on each apple, enlarge rapidly, run together, and the whole fruit becomes a soft, rotten mass. The disease usually begins while the fruit is still hanging on the tree, and as the disease progresses, many of the apples fall to the ground below.

Cause of the Rot.—This rot is caused by a fungus, known as *Glœosporium*, the spores of which fall upon the apple, grow, penetrate it, and cause the decay. The spores are produced in immense quantities in small pustules, which appear upon the rotted surface. In many instances the fungus passes the winter in cankered spots on the twigs and bark.

Treatment.—There are two forms of treatment, both of which should be followed.

First, inasmuch as the fungus is known to winter in the canker on the branches, it is important when the leaves are off the trees to carefully inspect the orchard, hunt out these cankers, cut them out and burn them, and thus remove the most dangerous source of spring infection.

Second, the trees should be sprayed with Bordeaux Mixture in order to kill all spores which fall upon the fruit or twigs. Spraying should be applied before the buds begin to swell in the spring, just after the blossoms fall, and every ten or fourteen days thereafter until the fruit is almost ripe.

These two treatments combined will, to a very large extent, serve to control this very serious disease.

[PRESS BULLETIN, No. 19, NOVEMBER, 1908.]

SUPPRESSION OF TERRAPIN BUGS.

(*Also known as Fire Bugs, Calico Bugs, Harlequin Bugs, and Collard Bugs.*)

BY R. I. SMITH, ENTOMOLOGIST.

SOME IMPORTANT FACTS.

As the remedial measures given below are based upon certain vulnerable points in the life-history of this insect, the following important facts are given:

1. Terrapin bugs hibernate during winter in the adult stage.
2. They may now be found on collard, turnip, cabbage, kale, and other cruciferous crops, as well as occasionally on other plants.
3. Terrapin bugs feed on the plant juices, obtained by means of a slender pointed beak. Hence they cannot be poisoned with arsenical sprays like Paris green.
4. Each individual may lay from ten to fifteen masses of twelve eggs each, or from one hundred and twenty to one hundred and fifty-six eggs. Occasionally a greater number are laid.
5. The period of egg-laying lasts about two months. In spring, the eggs require about eight to eleven days to hatch, but only three to four in hot weather.
6. THERE ARE ONLY THREE FULL BROODS ANNUALLY, but some bugs in all stages of development may occur in the fields as late as November.
7. THE BUGS WHICH BECOME ADULTS AFTER ABOUT SEPTEMBER 1 DO NOT LAY EGGS THE SAME FALL, but live over winter and produce the first spring brood.
8. Every adult female terrapin bug destroyed this fall might, if allowed to live, produce over one hundred bugs next spring.

WHY THE ABOVE FACTS ARE OF VALUE.

The above facts are pertinent, and some, especially NUMBERS 4, 6, AND 7, ARE NEW, and have been obtained by the writer as a result of a careful study of the terrapin bug—its habits and life-history—during the present year. This work shows quite conclusively that the farmer has a good opportunity to prevent a large part of the annual loss of thousands of dollars caused by the deterioration in the value of crops attacked by this destructive pest. The opportunity centers on the fact that all bugs maturing after about September 1 do not lay eggs the same season. If all adult bugs present during September, October, and November did lay eggs continuously, it would be a never-ending task to collect or to destroy them by spraying. The mature bugs are not easily killed by a contact spray like kerosene emulsion, although it will kill most of the young ones. Only a few eggs would be killed by spraying.

These facts are presented at this time in order to stimulate farmers and gardeners to fight the terrapin bugs NOW during the first days of November. It matters not whether the bugs are present in small or large numbers. It is certain that the bugs will have to be fought next spring and summer if they are not destroyed now; and just consider how much easier it is to catch and kill one terrapin bug at this time than it will be to wait and destroy her progeny next spring, numbering, perhaps, over one hundred.

HOW TO DESTROY THE BUGS.

In the opinion of the writer, there are only two effective methods of destroying terrapin bugs: one being hand picking and death by crushing or dropping in kerosene, and the other the use of a contact spray like strong kerosene emulsion, that will kill all the bugs it can be made to touch.

Hand Picking.—Unless the bugs are very numerous, hand picking is the most practical remedy. Children may do the work as well and even faster than grown persons. The bugs may be collected quite rapidly by picking all in sight and then shaking the plants and collecting those that drop. This work should be done on warm, sunny days, when the bugs are not in hiding, and one should not expect to get all at the first picking. Go over the infested plants two or three times, and on different days. The results from one thorough picking will, however, fully repay the farmer for his time and cost.

In fields in which the infected crop is of no further value, the plants may be pulled and piled in small heaps and left a couple of days until the terrapin bugs congregate on them, when the bugs may be readily killed by burning or treatment with pure kerosene. Be sure that the bugs are destroyed before they migrate to other feeding grounds.

Spraying the Crop.—This method is of some value, but is not strongly recommended for use at this time of the year. Kerosene emulsion at 25 to 30 per cent strength will kill many bugs, if it can be applied so as to cover them thoroughly. It is recommended mainly, however, for killing the small or half-grown bugs during summer. Where bugs occur on worthless plants, pure kerosene may be used with good results so far as killing the bugs is concerned, but the expense will often be more than would be required by hand picking.

By following the directions given above, thousands of dollars will be saved annually to North Carolina farmers.

[PRESS BULLETIN, No. 20, FEBRUARY, 1909.]

SPRING DESTRUCTION OF TERRAPIN BUGS.

BY R. I. SMITH, ENTOMOLOGIST.

The annual loss caused by terrapin bugs sucking the life out of collards, cabbages, turnips, and allied plants is difficult to estimate accurately, but certainly amounts to thousands of dollars in North Carolina. A large proportion of this loss may be prevented if farmers, gardeners, and truckers will take the trouble to collect or in some way destroy the bugs that first appear this spring. We have conclusive evidence that such work may be made a paying investment. We cannot, however, continue to wait, as is usually done, until the bugs become so numerous as to cause very noticeable injury in gardens or fields, but on the contrary they must be destroyed before they commence to lay eggs; otherwise the annual loss will remain the same or will increase.

In November last this Station published a press bulletin urging farmers to immediately collect and kill the terrapin bugs, then in their fields, to prevent their living in such numbers through the winter. Now it seems advisable to urge the equally important work of destroying those individuals that escaped last fall, and which will soon commence to come out from their winter hiding quarters.

ONLY ADULT BUGS SURVIVE THE WINTER.

Eggs and young bugs do not live through the winter in this State; hence it is only full-grown, strong, adult males and females which survive by finding favorable hibernating quarters under rubbish around the gardens, under stones, in fence corners and similar places, where they are protected from the weather. As this has been a mild winter, they are liable to appear in greater numbers than usual in the spring.

WHEN EGG-LAYING COMMENCES.

We could not consistently urge the task of destroying the overwintering bugs if they commenced to lay eggs upon their first appearance. Careful observation has shown that at least two weeks' time elapses after the bugs appear before the first eggs are deposited. During this period they are very actively feeding and mating, and the majority will congregate on the few old plants left from last season's crop. Wild mustard and turnips are favorite food plants, and collards, with their broad leaves, often harbor a large number of them.

The prime object of this article is to emphasize the fact that the farmer or gardener who watches closely for the first terrapin bugs to appear has about two weeks' time to kill them and still prevent the majority from laying eggs for the first generation.

RATE OF INCREASE.

Have you ever considered the actual benefit that results from killing one female terrapin bug when she first appears in spring, Observe the following statements: The average number of eggs laid by each bug varies from eighty-four to ninety-six—that is, seven or eight masses of twelve eggs each, deposited over a period of from four to eight weeks. There are three full generations each year. Suppose we kill a single terrapin bug and thus prevent ninety-six young for the first generation, of which one-half might be females. If these forty-eight females reproduced at the same rate, the second generation would number 4,608 individuals. Counting only one-half as females, each capable of producing ninety-six young, the third generation would reach the enormous number of 221,184, the progeny of one female in a single year. We can divide this number by one hundred and still have over 2,200 as the number of bugs prevented by killing one individual when she first appears.

During the warm summer months a minute parasite in the form of a tiny black fly destroys a large percentage of the eggs, but as a general thing these parasites do not become abundant until the first generation is well developed; so that the destruction of the bugs that produce the first generation is more essential than the death of bugs later in the year. Another point in favor of early destruction.

Are not the above facts sufficient to impress farmers with the importance of spring destruction of terrapin bugs?

HOW TO DESTROY THEM.

Hand Picking.—This is probably the most valuable method of killing terrapin bugs at any season of the year. The work can be done rapidly by children. The bugs are inclined to hide on cold, windy, or dark days; so that warm, sunny days should be selected for this task. We cannot expect to find all the bugs in one day, or even the majority of them. A good plan would be to collect two or three times a week, but be certain to commence within a few days after the bugs first appear. They may be killed by crushing or by dropping in a little kerosene.

Spray with Pure Kerosene.—When the bugs are abundant on worthless plants they may be killed with pure kerosene. With the aid of a small spray pump a large number of bugs may be killed in a few hours.

Arsenical poisons are not effective against this insect, which feeds by sucking the plant juice.

Kerosene emulsion of 15 or 20 per cent concentration is used with success for killing small or half-grown bugs, but this treatment will not kill many adults. By following the suggestions made above, the young bugs will not become numerous, but whenever spraying does become necessary kerosene emulsion is the best remedy to use.

BULLETIN 200 APRIL, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

FEEDING FERMENTED COTTON-SEED MEAL TO HOGS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

R. H. RICKS	Rocky Mount	J. T. ELLINGTON	Smithfield
W. D. TURNER	Statesville	W. E. DANIEL	Weldon
O. M. GARDNER	Shelby	W. H. RAGAN	High Point
LOCKE CRAIG	Asheville	W. B. COOPER	Wilmington
C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
W. A. SYME	Assistant Chemist
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant in Farm Crops
J. K. PLUMMER	Assistant Chemist
P. L. GAINEY	Assistant Bacteriologist
A. R. RUSSELL	Assistant in Field Experiments
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

PAGE.

Summary 4
Introduction 5
Object of experiment 5
Weight of animals, feeds and rations 6
Commercial value of feeds 7
Preparation of feeds 8
Conditions of experiment 8
Comparison of results by tables, with illustrations 9
Discussion of results 11
Gains by periods 14

SUMMARY.

Corn alone proved to be an undesirable ration for growing hogs, causing small gains and unthrift. This condition was more marked, owing to the fact that the lot was closely penned, without pasture; yet the other lots, similarly confined, made relatively larger gains.

Fermented cotton-seed meal can be fed in small quantities for limited periods, with very gratifying results. These experiments indicate that seventy-five to ninety days would be the limit of satisfactory feeding. This would depend, however, on the age and condition of the hogs, the supplementary feeds and the proportion of cotton-seed meal fed.

Lot 3, fed a combination of corn and cotton-seed meal, in the proportion of four to one, made larger and cheaper gains for the first ninety days than the lot similarly fed on corn and linseed meal. This would seem to indicate that, when possible, cotton-seed meal should be used, since it contains a larger quantity of protein and sells for about one-fourth less per ton than linseed meal.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to seventy-five-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of seventy-five to ninety days.

The feeding of the four lots of hogs during the first period was more profitable when one part of cotton-seed meal was added to the ration of four parts corn than when corn alone or corn and linseed meal in combination were fed. In case of linseed meal, however, the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor, and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately $28 per ton, the results of this experiment show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. While Lots 2, 3 and 4 have had a somewhat larger ration than Lot 1, the larger gains during the first period were sufficient to considerably overbalance this factor.

The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by Southern farmers. This experiment was carried on under adverse conditions to render safe conclusions possible.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is our cheapest commercial feed supplying protein, and should not be entirely ignored in swine production.

Cotton-seed meal, when fed in quantities, as given in this Bulletin, will, after a time—one hundred to one hundred and twenty days—apparently reduce the normal gains and profits therefrom. This point should be kept in the mind of the feeder, the amount of feed used recorded, and the hogs weighed occasionally. Accurate judgment will direct when to eliminate the meal from the ration. Aim to feed under the limit, however, rather than over.

FEEDING FERMENTED COTTON-SEED MEAL TO HOGS.

BY R. S. CURTIS, ANIMAL HUSBANDMAN.

The Experiment Station has frequently been questioned in regard to feeding cotton-seed meal to live stock. A large number of these inquiries relate to swine and the practicability of feeding cotton-seed meal to these animals. While this is not a new question, and we are aware that cotton-seed meal fed to swine in moderately large quantities is unsafe, frequently causing death, yet it seems highly desirable, when possible, to combine cotton-seed meal with high-priced corn, which is so generally used throughout the State. In making this combination of feeds, which seems especially desirable for growing hogs, because of the high protein content of cotton-seed meal, the feeder should be judicious in his methods and should be guided by the results obtained in this and other experiments reported. In the hands of a careful feeder, fermented cotton-seed meal may be used in small quantities, for a limited time, with good results, but for the indifferent and shiftless feeder it will most likely prove fatal to the growth and health of the animals, and if fed to extreme death will almost invariably result. While no deaths were recorded during this experiment, it is evident, as shown by the results in Table 1, that the last period of feeding was not as satisfactory as the first. The gains were much less and the cost more per pound of gain, and it is possible that the health of the animals might have been materially injured had the experiment continued for a longer time. Nothing definite can be stated in this regard, however, as the hogs were apparently normal when the experiment was completed.

OBJECT OF EXPERIMENT.

1. The experiment was conducted primarily to determine the amount of fermented cotton-seed meal which might be fed with economy and safety, in conjunction with corn, to young and growing hogs.
2. To determine the economy of gain from feeding cotton-seed meal in the proportions specified, and in comparison with corn alone, and with corn and linseed meal combined.
3. To determine the quality of the product produced by the different rations. This portion of the work will be reported in a subsequent BULLETIN.

WEIGHT OF ANIMALS, FEEDS AND RATIONS.

The average weight of the hogs at the beginning of the experiment was approximately 70 pounds. The rations fed to the four lots of hogs during the first period were as follows:

Lot 1. Corn.
Lot 2. Corn, 7 parts; cotton-seed meal, 1 part.
Lot 3. Corn, 4 parts; cotton-seed meal, 1 part.
Lot 4. Corn, 4 parts; linseed meal, 1 part.

The feeding was all done in dry lots, measuring 10 x 40 feet, and during a considerable portion of the time the weather was quite unfavorable for large gains. The quality of hogs was not of the best. They were of mixed blood, yet the division into lots was made in such a manner that practically all individuality was overcome. The low grade of the hogs accounts in part for the generally reduced gains obtained, although there were other unfavorable factors. From a comparative standpoint, however, the results are quite conclusive.

Lot 1.—Fed first period, corn alone; and second period, mixture of 4 parts corn and 1 part linseed meal.

On March 29, the end of the first period of three months, the rations were reversed and the lots of hogs were fed as follows:

Lot 1. Corn, 4 parts; linseed meal, 1 part.
Lot 2. Corn, 4 parts; cotton-seed meal, 1 part.
Lot 3. Corn, 7 parts; cotton-seed meal, 1 part.
Lot 4. Corn.

By reversing in this manner, Lots 2 and 3 still remained on the cotton-seed meal ration, since it was not desirable to cut off this part of the experiment, as one of the objects was to determine the amount of fermented meal which could be fed and the length of time this could be continued without the development of unfavorable results.

It is also important to know just when cotton-seed meal begins to show a detrimental influence on the health and thrift of the pig.

By reversing Lots 2 and 3 in the manner indicated, Lot 3 received all during the feeding trials a ration which conforms fairly accurately with our present idea of rational feeding. During the first part of the period the cotton-seed meal was fed in larger quantities to stimulate the growth of bone and muscle, while in the last period of fattening it was reduced just enough to balance the corn ration and at the same time keep within the bounds of safe feeding.

On the other hand, Lot 2 was fed only seven parts of corn with one part of cotton-seed meal during the first period, the results being less satisfactory than those obtained from Lot 3 during this period, as shown by Table 1. After reversing the ration and placing Lot 2 on a larger amount of cotton-seed meal, thus subjecting them to the meal gradually, the results were somewhat more satisfactory than those obtained during the second period of Lot 3, from the standpoint of the amount of feed eaten, pounds of feed used per pound gain, and cost of the gains. There was not enough difference, however, to warrant definite conclusions, as indicated by Table 1. The total gain made during the feeding period of six months was in favor of Lot 3, fed the larger quantity of cotton-seed meal during the first period. The results indicate that the linseed meal stimulated a relatively larger gain during the second period with Lot 1 than was made during the first period with Lot 1 when fed on corn. The corn alone caused larger gains during the second period with Lot 4 than was made with either Lots 2 or 3 during the corresponding period, when the hogs were fed cotton-seed meal as a supplement. This would seem to indicate that an all-corn ration is more effective in making gains during this period of feeding, and that either the nitrogenous supplement is not needed or the cotton-seed meal is detrimental after a certain stage of feeding.

During the feeding period of six months no signs of sickness were evident, and the increased gain made by Lot 3 during the first period shows plainly the desirability of adding limited quantities of the fermented cotton-seed meal to the ration for the length of time given in the results.

The hogs were weighed each week during the experiment, and a fairly substantial gain was made, especially during the first period, in favor of Lots 3 and 4.

COMMERCIAL VALUE OF FEEDS.

In placing a value on a feed stuff it is customary to take into consideration the actual cash value of that feed on the market. It is a fact, however, that if the farm products are fed and the manure placed on the land any man could afford to take actually less than market value when the same is marketed in the form of pork, and retain the manure on the land rather than sacrifice this valuable material. It should be the aim always to market home-grown products in the form of beef, pork or mutton, and thereby secure the increase over the market price of the feed, when the conditions are such as to make it possible.

In rating the feeds used in this experiment, the common practice has been followed of figuring them at the exact market value at the time the experiment was conducted. This was necessary, as no provision was made for determining the value of the manure at the time the experiment was planned.

The prices assigned to the different feeds were, for corn, $28; cotton-seed meal, $28, and for linseed meal, $35 per ton.

This places the cost of gains at a maximum figure; but if we were to actually determine the enhanced value to the land, where the hogs are properly bedded and the manure conserved and applied to the land, the cost of production would be materially reduced.

PREPARATION OF FEEDS.

During the winter months it was necessary to prepare the rations from two to three days in advance of feeding, in order to have them thoroughly sour. After the weather became warm, however, twenty-four to thirty hours were generally sufficient to bring about the desired condition. In preparing the feeds the shelled corn and combinations of cotton-seed meal and linseed meal with corn were weighed out into tin buckets, in the proper proportions, well mixed, covered with water and stirred thoroughly. The buckets were then placed on a shelf and allowed to stand until the rations were fed. The feeds for the four lots were all given the same fermentative treatment, as it was necessary to do this in order to correct any favorable or unfavorable results which might arise from soaking and fermenting the cotton-seed meal rations for Lots 2 and 3.

In every case, with the exception of Lot 1, the feeds were eaten with apparent relish. With this lot, however, a dull, stupid condition and depressed appetite developed with all the pigs after a lapse of three or four weeks.

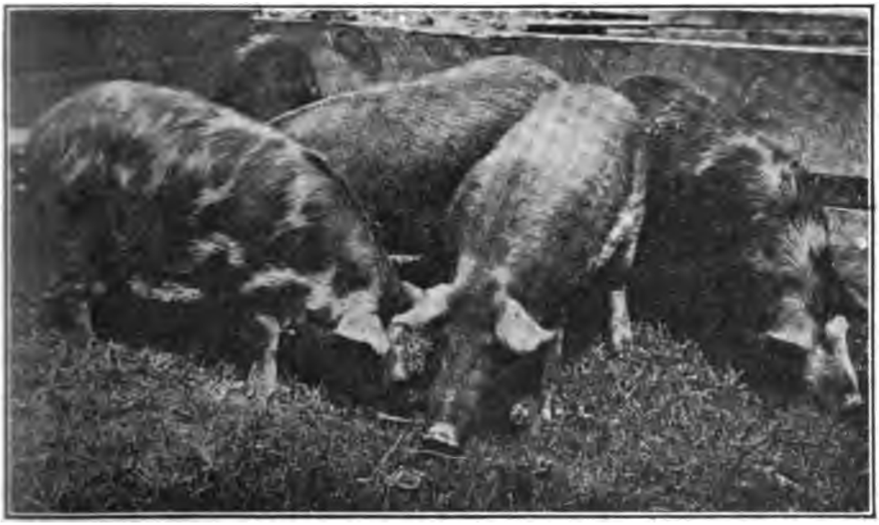
CONDITIONS OF EXPERIMENT.

The experiment proper was conducted for six months, beginning January 29 and ending July 29, 1908, and was divided into two periods of three months each. At the beginning of the second period the rations were reversed.

For the first three months of the final feeding period six pigs were used in each of the four lots, but during the last three months only five were used, because two "piggy" sows had to be removed from two of the lots. To balance this, one pig was taken from each of the other lots.

In making the division great care was taken to divide the hogs into lots of as nearly the same weight and type as possible, in order to eliminate individuality.

The pigs were all closely penned during the experiment—a condition most unfavorable for large gains with young hogs. The gains, without doubt, would have been greater had the hogs been allowed a run on green pasture; but as it was the desire to place them under the most unfavorable conditions, owing to the peculiar nature of the experiment, they were penned in dry lots. During the first feeding period especially, the muddy condition of the lots was partly responsible for the decreased gains made with the hogs as a whole.



Lot 2.—Fed first period, mixture of 7 parts corn and 1 part cotton-seed meal; and second period, mixture of 4 parts corn and 1 part cotton-seed meal.

COMPARISON OF RESULTS BY PERIODS.

The following table shows in a concise way the points of special interest brought out by feeding the four lots of hogs. The illustrations show quite clearly the marked differences in the quality of the lots. This is very strikingly shown in the case of Lot 1, which was fed on corn alone. The condition of the lot, as indicated in the cut on page 6, shows all evidences of unthrift. In case of Lots 2, 3 and 4 the difference is not so marked, although Lots 3 and 4 are smoother and more uniform throughout. The photographs were taken shortly before the conclusion of the experiment.

A close observation of the cuts by the reader may make it seem that the hogs in Lot 1, fed on corn alone, were decidedly inferior in quality. This was not the case, however, as particular efforts were given to the matter of selecting the hogs in each lot as uniformly as possible. The division was made according to weight, type and quality, which were distributed equally. An examination of the records will show that the weights of all lots were practically identical at the beginning of the experiment. The condition of the animals was also quite uniform. Outside of the different supplementary feeds used, the treatment of the four lots was the same. All were confined in feeding pens, where they were fed three times each day—morning, noon and night; and throughout the experiment a mixture of ashes, charcoal, lime, sulphur, copperas and turpentine was fed three times per week. The unthrifty condition of Lot 1 developed gradually, becoming especially noticeable after the first three or four weeks of feeding. As the pigs in this lot refused to eat their ration, it was reduced at times to an amount so small that one good, thrifty hog would have readily eaten it.

TABLE 1—SHOWING KIND AND PROPORTION OF FEEDS, WEIGHT OF HOGS AT BEGINNING AND END, AMOUNT OF FEED EATEN, AND COST OF GAIN.

	First Period—90 Days.				Second Period—91 Days.			
	Lot 1—Fermented Shelled Corn.	Lot 2—Fermented Shelled Corn and Cotton-seed Meal.	Lot 3—Fermented Shelled Corn and Cotton-seed Meal.	Lot 4—Fermented Shelled Corn and Linseed Meal.	Lot 1—Fermented Shelled Corn and Linseed Meal.	Lot 2—Fermented Shelled Corn and Cotton-seed Meal.	Lot 3—Fermented Shelled Corn and Cotton-seed Meal.	Lot 4—Fermented Shelled Corn.
Proportion in which feeds were fed	Corn Alone.	7:1	4:1	4:1	4:1	4:1	7:1	Corn Alone.
Average weight in pounds at beginning	73.30	75.30	75.30	75.10	97.40	122.00	141.40	135.00
Average weight in pounds at end	89.50	116.60	132.00	129.10	117.00	144.00	164.00	168.00
Average gain per head by periods	16.20	41.30	56.70	54.00	19.60	22.00	22.60	33.00
Average daily gain in pounds per head	.18	.46	.63	.60	.21	.24	.25	.36
Total pounds of feed eaten per pig	208.04	275.50	289.37	289.37	164.65	235.97	270.80	261.20
Average number pounds of feed consumed daily per pig	2.31	3.06	3.22	3.22	1.81	2.59	2.98	2.87
Pounds feed eaten per pound gain	12.84	6.67	5.10	5.36	8.40	10.72	11.98	7.91
Average number pounds of supplementary feed eaten daily per pig	.00	.38	.62	.62	.33	.46	.37	.00
Total number pounds of supplementary feed eaten per pig	.00	34.44	55.25	55.25	29.80	41.65	33.85	.00
Cost in cents per pound gain	18.00	9.33	7.14	7.86	12.30	15.00	16.70	11.07

DISCUSSION OF RESULTS.

The corn ration fed to Lot 1 proved to be very unsatisfactory. This ration is fed, however, to young hogs, in the majority of instances, in this State; and from the large number of bulletins which have already called attention to the excessive cost of production from feeding young hogs on corn alone, it seems as though the information should be widespread, and that farmers would be eager to discontinue the practice. Many farmers, however, are yet feeding high-priced corn to breeding and growing hogs, in the face of these facts.

The gain made by the six hogs in Lot 1 was 97 pounds during the first period. This is very little more than one good, thrifty shoat should have made in the same time, granting that the ration was made from proper feeds, containing sufficient protein and ash for muscle and bone production.

It required 12.84 pounds of feed to produce one pound of gain, representing a cost of 18 cents per pound. The average gain per day was only .18 pounds, whereas it should have been at least one-half or two-thirds of a pound, with a properly balanced ration.

During the last period, after changing the ration to a mixture of corn and linseed meal, the average gain per day was greater than during the first period. It required 8.4 pounds of feed to produce a pound of gain, one-third less than during the former period, which represents a cost of 12.30 cents per pound of pork. Had the pigs not been stunted by feeding on corn alone during the first period, the difference would in all probability have been much greater.

The fact should be considered that five pigs made a total gain of 98 pounds during the second period, whereas six pigs made a gain of 97 pounds during the first period. This gain is favorable to the corn and linseed-meal ration, which was fed under very unfavorable conditions.

Table 1 shows a marked improvement in the gains made by Lot 2 during the first period, when a small amount of fermented cotton-seed meal was fed. While the amount fed per day was less than one-half pound, the gain during the first period was .46 pound per day, with a consumption of 6.67 pounds of feed, representing a cost of 9.33 cents per pound of pork. While this is not in the bounds of profitable production, yet it shows a marked improvement over Lot 1, which was fed on corn alone during the first period.

During the last period Lot 2 made much less satisfactory gains than during the first period. The gain per day was very little more than one-half that made during the first period. This was made at a greater cost of feed consumed, 10.72 pounds per pound gain, which represented an actual cost of 15 cents per pound. While we would naturally expect the gains to be less during the last period, yet this small gain seems to indicate that there is a limit in feeding the meal, even though no toxic symptoms had developed in the animal before the close of the feeding period.

Lot 3 made very satisfactory gains during the first period, considering the conditions under which the hogs were kept. An average of .62 pound of cotton-seed meal was fed per day during this period, with an average daily gain per head of .63 of a pound. This gain represents the highest average made by any lot during the feeding trials. It required only 5.10 pounds of feed to produce a pound of gain, the gains being made at a cost of 7.14 cents per pound, which was the most economical gain made by any lot during the experiment.

Lot 3.—Fed first period, mixture of 4 parts corn and 1 part cotton-seed meal; and second period, mixture of 7 parts corn and 1 part cotton-seed meal.

The results seem to be clearly in favor of Lot 3 during the first period. Even when compared with the first period of Lot 4, it will be found that the gains made per day were greater and the cost per pound was less.

During the second period there was a marked decrease in the gains made per day by Lot 3. The .25-pound gain made during the second period represents only two-fifths of that made during the first, while the cost per pound was more than doubled.

This serves as a check on the results obtained in Lot 2, apparently corroborating the statement made that if the limitations in cotton-seed meal feeding are exceeded, the gains will be small and unsatisfactory, and even death may result.

With Lot 4 the results during the first period were very similar to those obtained with Lot 3 during the corresponding period. The average daily gains were practically the same, the amount of feed consumed was the same, and the amount of feed used per pound of gain was slightly in favor of the corn and cotton-seed meal ration. As to the cost of gain, there was a difference of 72 cents per 100 pounds in favor of the cotton-seed meal ration.

During the second period the results were reversed. The gains made, the amount of feed consumed per pound of gain, and the cost of gains were clearly in favor of the lot fed corn alone. These results point to the conclusion that ninety days or even less is the extreme limit in cotton-seed meal feeding, under the conditions here described. While we grant that corn would naturally be favorable to large gains during the last stage of fattening; we ordinarily accept the statement that a small amount of nitrogenous material would be helpful when fed in connection with corn. This was not true during the last period with Lot 3. The results were decidedly unfavorable to the meal, when compared with the second period of Lot 4.

For all practical purposes, a ration made up of four parts corn and one part linseed meal is, so far as the results obtained in this experiment are concerned, equal to a ration of corn four parts, cotton-seed meal one part. This is on a basis of efficiency, however, as the linseed meal costs more. Consequently the results would be less satisfactory, financially, when linseed meal was fed. This comparison does not hold good, however, after the first period of feeding, as we find by the results given in Table 1, that the gains made by Lot 4 during the second period were considerably more than the gains made by Lot 3 during the second period, when eating cotton-seed meal. The cost of gain on Lot 4 during the same period was also less than that of Lot 3 during the corresponding period. This again seems to point toward the fact that the limitations of meal feeding have been more or less accurately determined, not only in this experiment, but also by others reporting on the subject.

GAINS BY PERIODS.

The weights of the four lots of hogs at the beginning and ending of the two feeding periods were as follows:

TABLE 2—RATIONS AND GAINS OF THE HOGS BY LOTS AND BY PERIODS.

Lot Number.	First Period—90 Days.				Second Period—91 Days.				Total Gain of Lots for Two Periods—Pounds.
	Ration.	Initial Weight, January 29—Pounds.	Final Weight, April 28—Pounds.	Net Gain for Period—Pounds.	Ration.	Initial Weight, April 29—Pounds.	Final Weight, July 29—Pounds.	Net Gain for Period—Pounds.	
1	Corn	440	537	97	Corn, 4 parts; linseed meal, 1 part.	487	585	98	195
2	Corn, 7 parts; cotton-seed meal, 1 part.	452	700	248	Corn, 4 parts; cotton-seed meal, 1 part.	610	720	110	358
3	Corn, 4 parts; cotton-seed meal, 1 part.	452	792	340	Corn, 7 parts; cotton-seed meal, 1 part.	707	820	113	453
4	Corn, 4 parts; linseed meal, 1 part.	451	775	324	Corn	675	840	165	489

The gain of Lot 1, fed on corn and linseed meal during the second period, was practically the same as the gain made during the first period, when fed on corn alone. Large gains were not expected, however, during the second period, since the general condition of the animals had been greatly impaired by feeding them on the corn ration. The gain per pig was greater, however, since during the first period six pigs were used in each lot, and during the second period only five pigs were used.

This indicates that the addition of linseed meal to the ration during the second period had stimulated greater gains; and the fact that the gains made by Lots 2, 3 and 4 during the second period were materially decreased, as compared with the first period, would add some force to the statement that the limit of profitable cotton-seed meal feeding had been reached after seventy-five to ninety days. This fact could not be taken as conclusive evidence, however, as the addition of linseed meal to the ration of Lot 1 would naturally have an appetizing influence, which would stimulate in making relatively larger gains, and especially would this be so, considering the run-down condition of the pigs in this lot.

On the other hand, we have a factor always to be considered, and that is that the gains made during the last stages of fattening are always less than during the first part of the period, and that generally the cost is more per pound of gain. This, then, accounts partly for the results obtained with Lots 2, 3 and 4. How much to attribute to the detrimental influences of the cotton-seed meal during this particular stage of feeding is a question to be worked out later by extensive experiments.

It seems, however, in the case of Lot 3, that the gain during the second period is so small, absolutely and relatively, when compared with the gain made by Lot 3 during the first period, that the cotton-seed meal, after a certain time, becomes a disturbing factor. In the light of these results, and other evidence at hand, the period during which cotton-seed meal can be fed profitably will depend on the amount of cotton-seed meal fed, the size of the hogs and the general feeding and management. In this particular case seventy-five to ninety days was the maximum limit, and even in the case here mentioned the gains were not profitable. The writer is of the opinion that, under a proper system of management, especially if pasture or some suitable grazing crop is supplied, the gains would have been made profitably, at least, certainly more so than when corn alone or a mixture of corn and linseed meal was fed.

Lot 4.—Fed first period, mixture 4 parts corn and 1 part linseed meal; and second period, corn alone.

Lot 2, during the second period, made a gain of 110 pounds, against 248 pounds during the first three months. Their ration was the same in both periods, except that the proportion of cotton-seed meal given during the second period was greater than during the first. The difference in the gain made by this lot during the first and second periods could be more easily accounted for than in the case of Lot 3, since in the latter the cotton-seed meal was reduced, making a more highly carbonaceous ration, from which we would naturally expect comparatively rapid gains, considering the commonly accepted views on feeding. There is not enough evidence, however, in the case of Lot 2, to conclude that the cotton-seed meal had any influence in checking the gains, since naturally they would be decreased somewhat.

On the other hand, Lot 3, fed corn and cotton-seed meal in the proportion of four to one during the first period, and seven to one during the second period, made a gain of only 113 pounds during the latter, as against 340 pounds during the former period, which was more than three times as much gain in the first as in the second period. It is possible that this extreme difference might be attributed to the age and condition of the animals during the latter period, yet it does not seem that the decrease would be so great on hogs capable of taking on more flesh and fat, as was the case with this lot.

Lot 4 made a more substantial gain, it being 165 pounds during the second period, as against 324 pounds during the first period. This, however, we would naturally expect, to a certain extent, as corn is a fattening ration, and was given at a time when hogs would make the best use of it. After making a good growth of bone and muscle on feeds such as a combination of corn and linseed meal furnished during the first period, larger gains were made than would have been otherwise.

In case of Lot 4 some strength is given to the claim that cotton-seed meal does influence unfavorably the normal gains after a period of about three months. It is a commonly accepted fact that a small amount of protein feed, such as linseed meal, tankage, etc., added to a corn ration, will make the gains larger and at times more profitable. It would therefore seem that the cotton-seed meal fed to Lot 3 during the second period was given in about the right proportion to induce larger gains. Such was not the case, however, as the meal was a detrimental factor, as Lot 3 made only 113 pounds of gain during the second period, while Lot 4 made 165 pounds, or about one-third more gain than Lot 3. Whether this difference in gain can be attributed to the peculiar physiological effect of the cotton-seed meal is to be determined later. These results seem to point toward such a conclusion.

BULLETIN 201 APRIL, 1909

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
OF THE
COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

SCUPPERNONG AND OTHER MUSCADINE GRAPES: ORIGIN AND IMPORTANCE.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

R. H. RICKS	Rocky Mount	J. T. ELLINGTON	Smithfield
W. D. TURNER	Statesville	W. E. DANIEL	Weldon
O. M. GARDNER	Shelby	W. H. RAGAN	High Point
LOCKE CRAIG	Asheville	W. B. COOPER	Wilmington
C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
W. A. SYME	Assistant Chemist
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant in Farm Crops
J. K. PLUMMER	Assistant Chemist
P. L. GAINEY	Assistant Bacteriologist
A. R. RUSSELL	Assistant in Field Experiments
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

PAGE.

History of the Scuppernong.................................... 5
    Confusion Regarding Early History.......................... 5
    Collecting the Facts....................................... 7
    Original Scuppernong Vine.................................. 7
    Naming the Scuppernong..................................... 8
    Origin of the Word "Scuppernong"........................... 9
    Early Names of the Scuppernong............................. 10
    Old Vines on Roanoke Island................................ 10
Scuppernong a Muscadine Grape.................................. 10
Importance and Characteristics of the Scuppernong.............. 11
Other Important Varieties of *Vitis Rotundifolia*.............. 13
    Varieties with Dark-colored Fruit.......................... 13
    Varieties with Light-colored Fruit......................... 17
    Varieties with Reddish or Reddish-purple Fruit............. 18
    Unimportant Varieties 19
Men Who Popularized the Muscadine Grapes....................... 19
Recommendation of Varieties.................................... 19
Importance of Muscadines in the South.......................... 19
Muscadines in North Carolina................................... 20
Muscadines for Market.. 20
Unfermented Grape Juice.. 20
Self-sterility in Muscadine Grapes............................. 21

ORIGIN AND IMPORTANCE OF THE SCUPPERNONG AND OTHER MUSCADINE GRAPES.

BY F. C. REIMER, HORTICULTURIST.

One of the most important things connected with the introduction of a new fruit is a careful study of the conditions which surround the plant in its native home. In the planting of fruits during the past, often too little attention has been given to this matter. The home of a species usually indicates the locality or localities that it is best suited to. It determines in a large measure where that fruit can be grown and where it is likely to give best results. A species is more or less a product of the locality in which it originated, as the conditions prevailing there have in a large measure produced it. By natural selection, nature eliminates those forms not adapted to the environment.

This principle is well illustrated by our native fruits. The grapes of the eastern portion of the United States are far better suited to that section than any of the foreign species. This is also true of our native species of plums, blackberries, dewberries and raspberries.

The same principle applies particularly to varieties. A variety is usually best suited to the particular section in which it originated. The varieties of apples, peaches, pears and plums best suited to the Southern States are those which have originated in the South: for example, the Red June and Bonum apples, the Greensboro and Lady Ingold peaches, which originated in this State, reach their greatest perfection here.

The history and development of most of our important native fruits has been determined and recorded. Bailey and Munson have traced the development of our leading species of grapes, except *Vitis rotundifolia*—the Muscadine grape—on which practically nothing has been done. It is rather difficult to determine why this is true, as it is by far the most important species of grape in the South. The history of the different varieties of the Muscadine grape should be fully determined and preserved. This species has always been a very interesting one to North Carolinians, as it is native to the eastern half of the State, and most of the varieties have originated there.

HISTORY OF THE SCUPPERNONG.

Confusion Regarding Early History.—The following opinions have been offered regarding the origin of the Scuppernong: that it is a foreign variety introduced into this country many years ago; that it is a native of Virginia and was brought to North Carolina by the early settlers; and that it is a native of North Carolina. Of those who hold to the last belief, some claim Tyrrell County and others Roanoke Island as its original home.

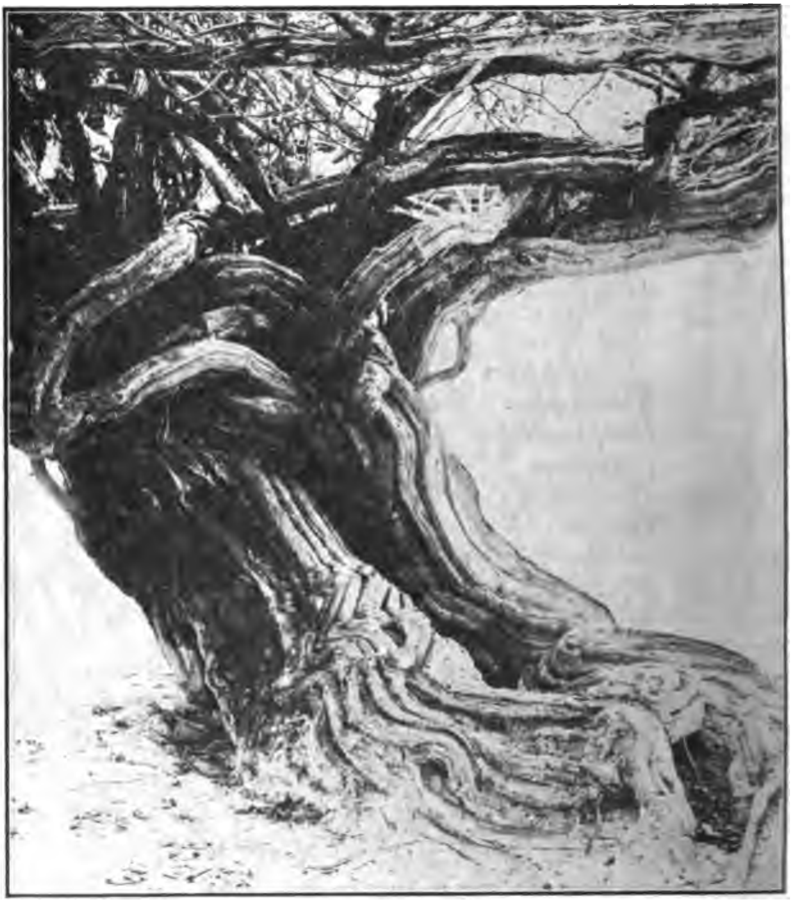


Fig. 1.—Characteristic Old Scuppernong Trunk.
(Circumference seven feet six inches.)

Although much has been written regarding this variety during the last half century, no one has indicated how and when the name "Scuppernong" was assigned to it. It is believed by some that this honor belongs to the North Carolina Indians; by others, that it belongs to the early white settlers. Some maintain that the name was taken from Scuppernong River, and others that Scuppernong River was named for the grape.

The writer determined long ago to clear up this confusion. The history has been determined, and the facts, we believe, are of importance to the grape industry of this State and the South, and to horticulture in general.

Collecting the Facts.—It was first necessary to review all of the old books, magazines and periodicals on Southern horticulture and agriculture, especially those on grapes; but very little information could be found regarding the origin of this grape. The most important facts were obtained from files of the old newspapers of the State, especially those published during the early part of the nineteenth century. Information of considerable value was also found in some of the old State and family records.

The writer made an extensive trip to all of the old grape sections in the eastern part of the State. All of the old vines of which any record could be found were examined and carefully measured, and their history was determined as fully as possible. Interviews were held with the descendants of the earliest grape growers; and in this way facts were obtained that throw much light on the subject.

The Original Scuppernong Vine.—It seems to be impossible to locate with absolute certainty the original Scuppernong vine, as no authentic records of the original vine can be found. This, of course, is perfectly natural, as little or no interest was taken in recording the history of any fruits at that early date. The writer feels certain that the original vine was found in northeastern North Carolina, and probably in Tyrrell County.

The earliest authentic record that we have of this grape comes from New Bern, North Carolina. According to a letter by Judge Gaston, dated June 4, 1838, his old neighbor, a Mr. Hickman, brought a young plant of this grape from Tyrrell County, about 1760, and planted it near New Bern, where it became generally known as the Hickman grape.

The most reliable information to be obtained regarding the finding of the original plant of this grape was supplied by the great-granddaughter of the supposed discoverer, Isaac Alexander. The history which has been handed down verbally from generation to generation in that family is, in substance, as follows:

Isaac Alexander went from Mecklenburg to Tyrrell County about the middle of the eighteenth century to take possession of a tract of land granted to him by the English king. In exploring the region, he found not far from Albemarle Sound a wild grapevine bearing large, luscious white grapes. It is said that this was the original vine which many years later was named Scuppernong.

As that region became settled, the vine was rapidly propagated, and, according to several authentic articles, nearly every home in the locality had near it at least one of these vines at the opening of the nineteenth century. It was soon discovered that this grape made excellent wine, and as early as 1809 extensive plantings of it could be found in the vicinity of Lake Scuppernong. The grape was commonly spoken of as the White Grape.

On December 21, 1809, the following letter, written by Governor Smith, appeared in *The Star,* a newspaper then published at Raleigh, North Carolina:

"Description of an extraordinary and excellent kind of grape produced in the northeastern part of North Carolina, but not generally known even in that State.

"The grape is large and sweet, of the species of the Fox grape, but white; has been cultivated a number of years in the neighborhood of Lake Phelps, but it is not clearly understood whence it originated. It is supposed to be a native. There are few settlers about the lake but what have a grapevine, which is generally planted at the root of some large mulberry, beech or oak tree, or trained along an arbor of poles lying on forks high enough for a person to walk under and gather grapes conveniently. The vines are never pruned, but suffered to run in a rude state, and many people have vines that will make them a barrel of wine.

"The wine is made by gathering the ripe grapes, picking out all those which are green or bruised, and squeezing the juice into a cider press as soon as they are gathered (for if they lie from one day to another the juice will sour and the wine will always have that taste), when it is put in a clean barrel. To every three quarts of grape juice one quart of brandy is added. After three or four days the wine is raked off till it is clear, and when it gets age is much approved of.

"The process above mentioned is that now followed, but as there are several gentlemen of information sending to the people in that neighborhood to make wine for them, a better process may be discovered. Some have tried fermentation, but it did not answer."

Naming the Scuppernong.—On January 31, 1811, *The Star* published under the heading, "North Carolina Wine from Native Grapes," part of a report made by James Blount, of Scuppernong, North Carolina, who had been appointed to take the census of Washington County. In this report he states that Washington County produced thirteen hundred and sixty-eight gallons of wine from native grapes during 1810. Mr. Blount in his report further says:

"Having taken an account of the wine in my division, I think it my duty to state the result of my inquiries on this small but very interesting branch of our infant manufactures.

"The large white grape from which most of this wine is made is said to be a native of America, and probably of North Carolina, as no person can tell its origin; and I feel inclined to join in this opinion, having about three years ago found a vine with ripe fruit on it of this kind in the woods, where it is very improbable it could have been planted. I am told the grape from the seed will be purple and larger than from the cuttings of the vine, though not so sweet. These vines thrive well on various kinds of soil, but delight most in that which is loose and sandy, and if care is taken to manure them for two or three years it will afterwards only be necessary to keep the weeds clear, prune and scaffold them; and one vine is worth more than fifty apple trees."

The editors of *The Star* add the following comments to Mr. Blount's report:

> "Our readers will recollect a communication on this singular and excellent species of grape (which for the sake of distinction, until we are better instructed, we shall denominate the Scuppernong Grape) in the 239th page of our first volume. That communication excited considerable interest and procured for us another favour of the same kind from Mr. Cooper, which will be seen in page 38 of our second volume."

The grape was named "Scuppernong" because of the numerous plantings of this variety along the Scuppernong River at that time. The name was also given as a compliment to James Blount, who lived near that river and whose excellent articles on this grape attracted much attention at that time.

At that time, Dr. Calvin Jones and Thomas Henderson were editors of *The Star*. The honor, then, of naming this grape belongs to the editors of a Raleigh (North Carolina) newspaper. It is very probable that it should properly be given to Dr. Calvin Jones, who was a noted naturalist, and edited the agricultural part of *The Star*.

The writer feels certain that this is the first time that this grape was designated as *Scuppernong*. He has not been able to find this name used in any of the earlier writings; and Blount, in his report two years previous to that date, speaks of it as "the large White Grape." The following extracts from a letter written by James Saunders of Chowan County, North Carolina, to the editors of *The Star* and published in that paper April 17, 1812, under the title "Scuppernong Grapes and Wine," also lead to the same conclusion:

> "Your publishing with such lively interest the properties of that excellent fruit you have named the 'Scuppernong Grape,' while it appeared you were yourselves quite a stranger to it, has induced me to endeavor to prepare and convey to you, this fall, a few slips of that valuable and most luxurious article.
>
> "The usual or common name given those grapes here is the 'White Fox.' So far as my information goes, I think it is most probably a native of Roanoke Island, near Roanoke Inlet, where some have conjectured Sir Walter Raleigh either found or left them. However, I have heard no person object to the name you have given, nor do I expect that any will, for the neighborhood about Scuppernong for several years has abounded with them, and for some time past the inhabitants have been turning them to good account, and, with the help of the encouraging Star, this branch of economy and industry may be brought to high perfection."

Origin of the Word Scuppernong.—The word Scuppernong is a corruption of the Indian word *ascuponung,* meaning place of the ascupo, ascopo, or askopo. The word *ascopo* was the Algonquin Indian name for the Sweet Bay (*Magnolia glauca*). This tree is very abundant along the Scuppernong River.

On the old maps of the State we find that the word *ascuponung* was gradually changed until it has become badly corrupted. Eman Bowen gives it as *cuscoponung* in 1752. On a map by Joshua Fry, published a little later, it is given as *cusponung.* In 1770 John Collet changes it to *Scuponung.* In 1771 James Cook again changes it to *Scuponing.* Some time between 1775 and 1800 it was finally changed to *Scuppernong.*

Early Names of the Scuppernong.—During the early history of this grape and before the name Scuppernong became generally used, it was known by different names in different localities. The original name was the White Grape. Around New Bern, North Carolina, it was known as the Hickman grape, having been named for a Mr. Hickman who introduced it into that locality. It has also been designated as the Roanoke Grape, White Scuppernong, and Green Scuppernong.

Old Vines on Roanoke Island.

It is often stated that the original Scuppernong vine is still growing on Roanoke Island, where it was first found. The writer feels quite certain that this is a mistake. He examined these vines on Roanoke Island carefully and found that there are five vines of about equal age that undoubtedly were planted there, as they stand in two straight rows. It is true that these vines are very old, but certainly not as old as some in Tyrrell County.

It is not definitely known who carried the young plants of this grape from Tyrrell County to Roanoke Island, but as there was considerable traveling and trading between this island and the mainland along Albemarle Sound, it is readily understood how the vine or vines could have been carried to the island.

It is stated by some that the vines were carried from Tyrrell County to Roanoke Island by Ann Ashbee. This may be possible, as Ann Ashbee in 1799 married Maurice Baum, who in 1797 had purchased the property on Roanoke Island on which the old vines now stand. Certain records seem to indicate, however, that these vines were planted at an earlier date.

SCUPPERNONG A MUSCADINE.

The Scuppernong is a variety of the Muscadine grape, *Vitis rotundifolia,* which grows wild abundantly all through the eastern part of the State. Some writers dispute this, but it is difficult to understand how anyone who has seen the Scuppernong and the wild Muscadine vines can conclude that the Scuppernong is not a native grape. The variety has every characteristic of that species. The trunk, vines, aerial roots, tendrils, leaves, and flowers are characteristic of this species. It is true that the fruit of the Scuppernong is light or whitish in color, while that of the Muscadine is usually dark-purple or black. Still we know that the black Fox grape, *Vitis labrusca,* often produces white-fruited seedlings. Many species normally producing black fruit now and then produce forms which yield white fruit.

Furthermore, the writer has seen a wild Muscadine vine bearing white fruit. (See Fig. 2.) It was found growing wild in the woods on Roanoke Island. He has also seen two white-fruited Muscadines now growing on the farm of J. A. Swain, Columbia, North Carolina, which were found in the woods near Columbia, by his father, Timothy Swain. Still further proof is that most of the seedlings of the Scuppernong have purple or black fruit and are as typical Muscadines as can be found anywhere. Then, too, the Pee Dee grape is a white-fruited Muscadine that was originally found growing wild in South Carolina.

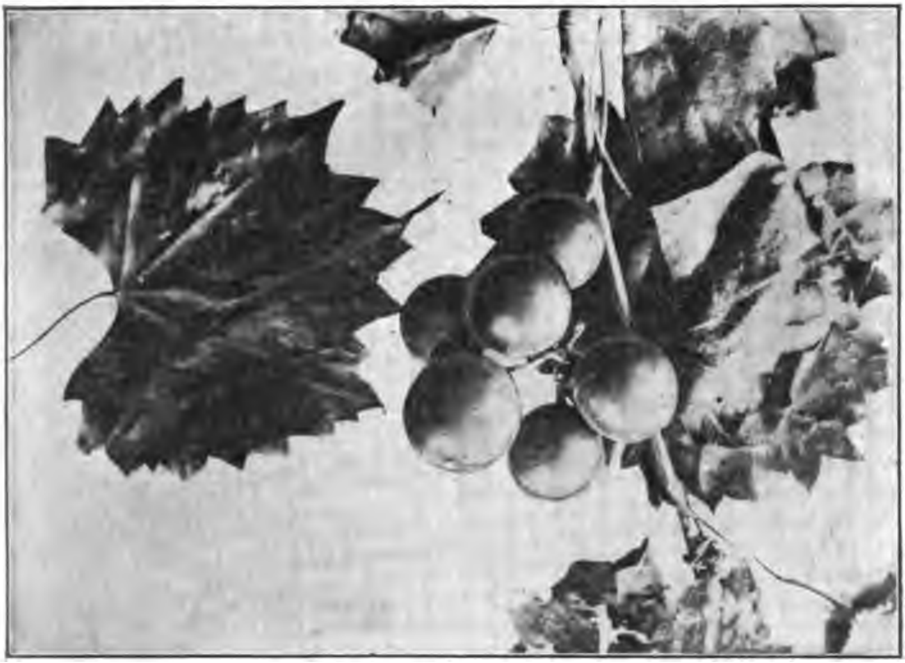


Fig. 2.—Wild White Muscadine.

IMPORTANCE AND CHARACTERISTICS OF THE SCUPPERNONG.

The Scuppernong was the first American or native grape to be brought into cultivation. It has always been the most important variety of this species and has been more generally planted than all of the other muscadines combined. It became popular as soon as introduced because of its great hardiness—growing and bearing well under neglect, and producing an excellent table grape and wine.

The vine is a vigorous grower and attains immense size, as is seen by Fig. 1, which shows a Tyrrell County vine measuring seven feet six inches around the trunk. It is notably healthy, not being seriously affected by either insects or diseases, and is generally a regular and heavy bearer when growing on suitable soils. It is long-lived; some of the vines now bearing good crops are more than a hundred years old. One marked peculiarity of the vine is the splitting-up of the main trunk into several divisions, when it becomes very old; also the production of aerial roots when trained on arbors. The vine can be quite readily distinguished from the dark-fruited varieties by the light-colored ends and nodes of the young shoots, the whitish or light-green tendrils and new growths of the aerial roots.

The flowers are perfect, and appear during June in North Carolina. Flowers (and fruit) are borne on the new wood, and not on the old wood, as some of our popular writers have stated. The clusters vary considerably in size, containing from one to twenty-five berries, usually being much larger on sandy than on clay soils. The berries are round, large, often becoming an inch in diameter; the color varies from pale green to golden russet; skin thick but tender for a Muscadine. The pulp is tender, juicy, with a sweet, rich, characteristic aromatic flavor; and the quality is very good, especially when grown on sandy soils. The chief defects of this grape are the readiness with which the berries shatter from the cluster when fully ripe, and the

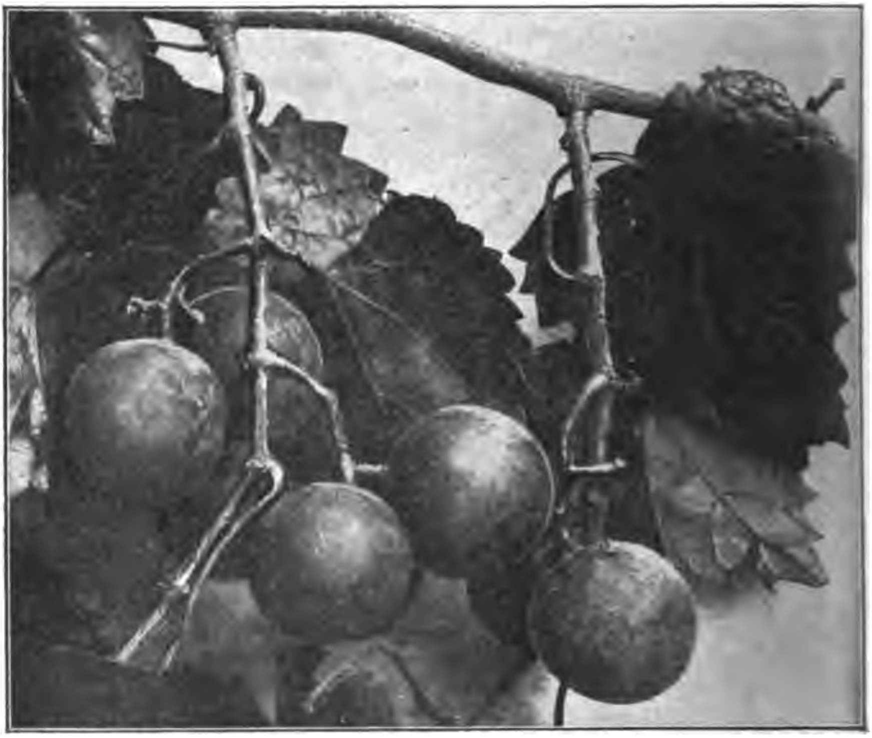


Fig. 3.—Scuppernong.

irregularity of ripening of the berries even on the same cluster. The ripening period covers the entire month of September in North Carolina.

The Scuppernong is distinctly a wine grape. It makes a rich, light-colored wine, which has no superior among sweet wines. The large plantings in this State, some of which cover from one hundred to six hundred acres, were made primarily for wine production. A bushel of fruit will produce from three to four gallons of wine.

It is also a good table grape when used soon after gathering; but as the skin is often broken, in picking, where the stem is attached, the fruit sours readily during warm weather. It cannot be shipped successfully except when used for making wine.

This is distinctly a grape for sandy soils, and should never be planted extensively on heavy clay. It is more productive, and the clusters and berries are larger, more juicy and of better quality on sandy or sandy-loam soils than on clay soils.

OTHER IMPORTANT VARIETIES OF VITIS ROTUNDIFOLIA.

Varieties With Dark-colored Fruit.

Flowers.—This excellent late grape comes from Robeson County, North Carolina. It was discovered early in the nineteenth century by William Flowers, about sixteen miles south of Lumberton, in Flowers Swamp. In 1816, Giles Williams visited the parent vine for the purpose of obtaining cuttings. He states that the vine then had the appearance of being about ten or twelve years old. As the fruit of this variety ripens very late and makes an excellent red wine, it soon became the leading black grape in the South for wine making. This is the most popular late variety of this species, the fruit being at its best the latter part of October and during November. The vine is unusually vigorous and is a very heavy bearer. The clusters are large and contain from ten to twenty-five berries, which are large, slightly oblong, purple to black in color, and cling to the cluster unusually well, being equal to any of the bunch grapes in this respect. This is due to the stem being attached on the inside of the fruit, into which the fibro-vascular bundles extend from one-eighth to one-fourth of an inch. This is an important characteristic, as it enables the fruit to be shipped long distances without the shattering of the berries which usually occurs with most of the varieties of this species. The pulp is rather hard and harsh and the flavor is inferior to that of most of the other varieties. For table purposes it has little to recommend it except its late ripening season. For wine making it has no superior; and it will probably make excellent unfermented grape juice. The large clusters and the clinging quality of its berries seem to commend it for breeding work.

Flowers Improved.—This variety was found by J. M. Shipman, about 1869, near Red Hill Swamp, nine miles north of Whiteville. North Carolina. As it has been only locally advertised, it is not generally grown. The variety has a great deal to recommend it, being superior in some respects to its parent, the Flowers. The vine is more vigorous and more productive; the fruit is similar to the Flowers, but the clusters are larger and the berries more oblong and cling tenaciously to the stem, which is attached internally. It ripens as late as its parent, and for wine making and breeding work seems to be equally promising.

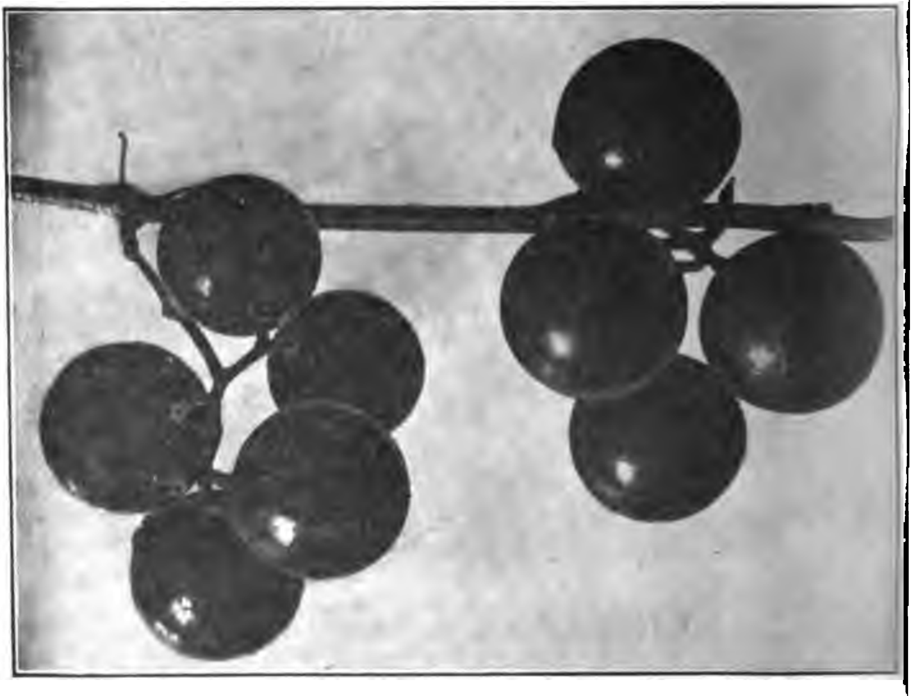


Fig. 4.—James.

James.—This is a native of Pitt County, North Carolina. It was found by B. M. James, in 1866, about three miles south of Parmele, on the Weldon and Kinston Railway. Mr. James was attracted to the grape because of the very large size of the individual berries, and by the fact that they remained on the vines in perfect condition until very late in the season. He propagated the variety and sold it quite extensively. At present it is probably the most widely planted and most popular black grape of this species. The vine is very vigorous and productive; the clusters are of medium size and contain from five to fifteen berries, which are bluish-black in color and are the largest of any in this group, often measuring an inch and a quarter in diameter. The skin is thin, the pulp tender and juicy, and the quality very good. The chief defect of this variety is the readiness with which the berries shatter from the cluster as soon as ripe. It is much better suited to clay soils than the Scuppernong and is probably the best general-purpose variety of the group.

Hopkins.—This grape was originated near Wilmington, North Carolina, about 1845, by John Hopkins, an English gardener, who came to that place in 1840. It is said to be a cross between a wild black grape and the Scuppernong. It is not known at present what the wild black grape was, but it is very probable that it was a muscadine. Others maintain that this variety is simply a superior seedling of the Scuppernong. As the fruit of this grape ripens earlier than

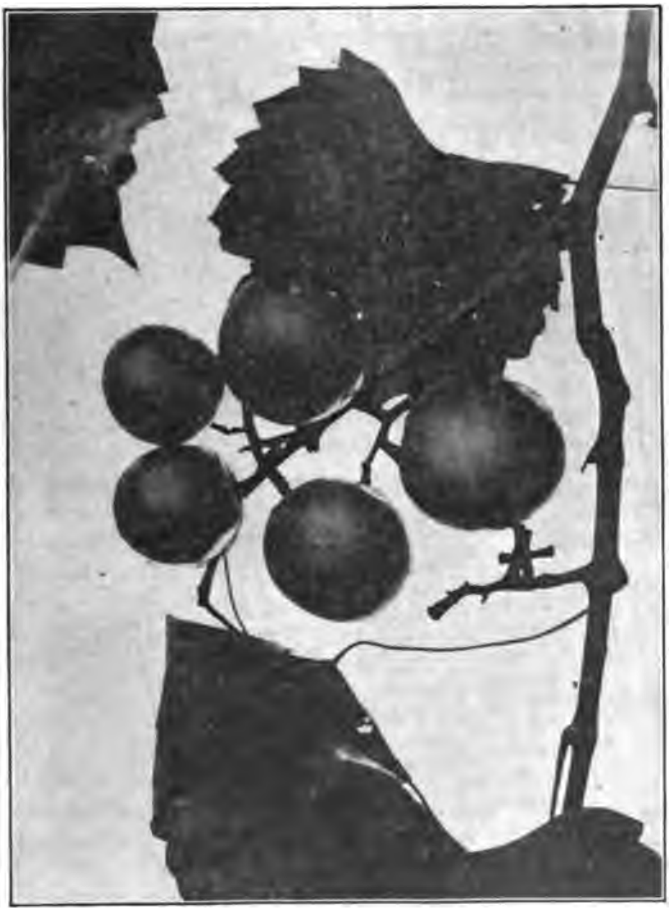


Fig. 5.—Memory.
(Clusters usually larger than that illustrated.)

that of any others belonging to this species, and as it is of excellent quality, it is rather strange that this grape has not been more widely grown. The vine is exceedingly vigorous and healthy, the clusters and black berries are large, the pulp is tender, and the flavor unsurpassed. This variety is a valuable member of this group, as it lengthens the ripening season nearly a month, beginning early in August. It should be found in every home vineyard.

Memory.—The Memory was introduced, in 1868, by the late T. S. Memory, of Whiteville, North Carolina. Some of its characteristics and the fact that it was found in his vineyard among some Thomas grapevines indicate that it is a seedling of the Thomas. The grape proved to be an excellent one, and Mr. Memory named it for himself. The vine is probably the most vigorous grower of this group. The fruit ripens in September; the clusters are of good size, and the berries cling to the clusters until they become shriveled. The berries are very large, oval to oblong in shape, and jet-black in color. The pulp is juicy, very tender, exceedingly sweet and delicious. This variety has not become as widely distributed as its good qualities merit. It should be in every home vineyard, and for local market it has no superior in this species.

Mish.—This variety was found by William Henry Mish, about 1846, at Swann Point, on the Pamlico River, about six miles east of Washington, North Carolina. He found it growing in the sand twelve or fifteen feet from the river. The variety was named for the finder and introduced by him shortly after being discovered. It soon attracted much attention and was widely planted throughout the South. Extensive plantings of it can be found at present around Washington, North Carolina. The vines are vigorous and very productive. The clusters are large; the berries medium in size, round, purplish in color, and adhere well to the clusters. The pulp is tender, juicy, very sweet and of exceptionally fine quality. This variety should be planted in every vineyard, because of its fine flavor and good shipping qualities.

Sugar.—This is another variety introduced by the veteran grape grower, T. S. Memory, of Whiteville, North Carolina. It was found by him at Whiteville, between 1865 and 1870. The variety has never been widely grown, and at present the writer is able to locate only a few vines of it. It does not possess any special characteristics to commend it.

Tenderpulp.—Tenderpulp originated in the vineyard of D. P. High, at Whiteville, North Carolina, about 1868. It is very likely a seedling of the Flowers. Although the pulp is very tender, it is low in sugar content, and of poor quality. It has nothing to commend it except its exceedingly tender flesh, and its productiveness. Because of its poor quality, it has never become very popular.

Varieties With Light-colored Fruit.

Pee Dee.—The Pee Dee was discovered by some negroes on Dr. H. Williamson's place at Darlington Court House, South Carolina, just prior to the Civil War. During the war, it was brought to Dr. Williamson's attention. It was undoubtedly an accidental seedling, as it was found growing over a fence where everything seemed to indicate that it had not been planted. This variety never became very popular or widely distributed and at present is seldom met with. It is an interesting variety because the color of the berries is similar to that of the Scuppernong. It has nothing to commend it over that variety except its late ripening habit. For wine and jelly it is excellent.

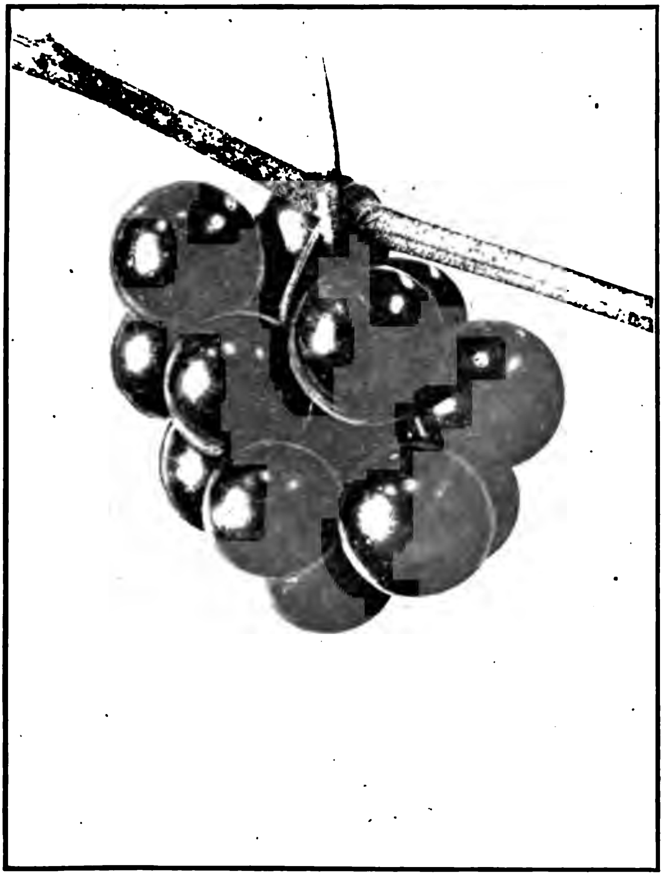


Fig. 6.—Mish.

Varieties With Reddish or Reddish-purple Fruit.

Thomas.—This excellent variety was found about 1845, in the woods four miles from Marion, South Carolina, by Drewry Thomas, and takes its name from Mr. Thomas, who introduced it. The variety at once became popular because of its delicious sweetness, and has been widely planted. It is unique as a muscadine because it is the only variety of the species that has reddish or reddish-purple fruit. The vine is not a vigorous grower, but is very productive. The clusters are large, and the berries shatter readily when fully ripe. The fruit ripens early, and the berries are small, round, reddish, with a thin, tender skin. The pulp is tender, juicy, sweet, and exceptionally rich. As a table grape the quality could hardly be im-

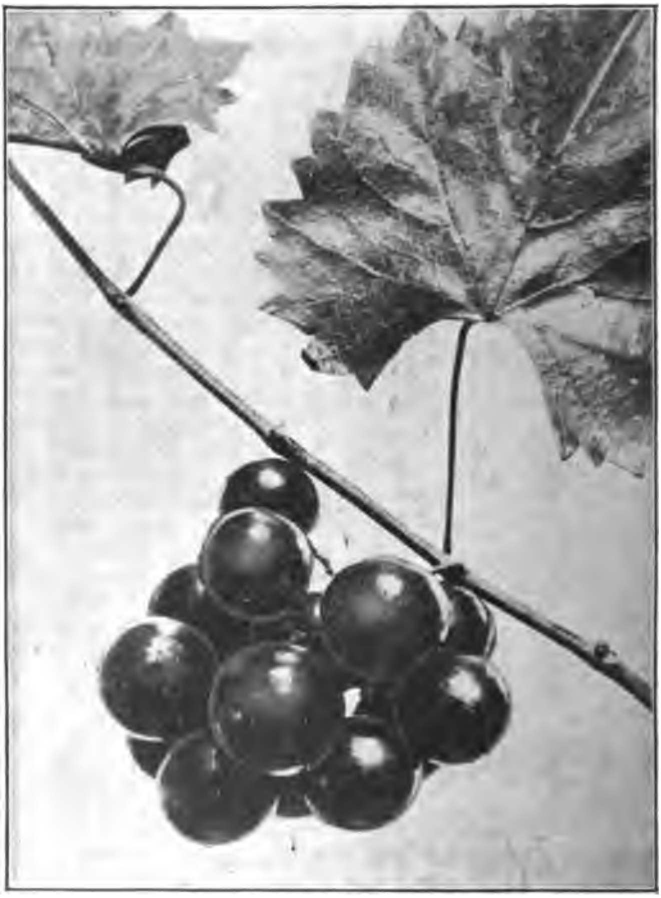


Fig. 7.—Thomas.

proved on. The only other variety that equals it in this respect is the Memory. It should be planted in every vineyard, and if but one variety is to be planted for home-use, Thomas is the variety.

Unimportant Varieties.

There are several varieties of this species grown only locally, and it is quite probable that they will never be widely grown, or become of any special importance. Such varieties are Beula, Westbrook, Jeter, and Seedlin.

MEN WHO POPULARIZED THE MUSCADINE GRAPES.

Since North Carolina is responsible for the introduction of most of the varieties of this species, it is only just to mention the names of the men who were largely responsible for their introduction. These men were Thomas Blount, of Washington County; Hickman, of Craven County; Calvin Jones, of Wake County; Sidney Weller, of Halifax County; Henry Mish, of Beaufort County; T. S. Memory and D. P. High, of Columbus County; L. Froelich, of Duplin County; and J. Van Buren, of Georgia.

RECOMMENDATION OF VARIETIES.

a. For home use:
    Hopkins, Thomas, Scuppernong, Mish, Memory and Flowers Improved.
b. For wine:
    Scuppernong, James, Flowers and Flowers Improved.
c. For unfermented grape juice:
    James, Mish, Memory and Flowers.
d. For general market:
    Mish, Memory and Flowers Improved.

IMPORTANCE OF MUSCADINE GRAPES IN THE SOUTH.

The varieties of this species have always been the most important grapes in the warmer sections of the South. They are especially well adapted to the climatic and soil conditions of the Coastal Plain region from southeastern Virginia to Texas. The vines grow luxuriantly, and as the bloom appears very late, they are regular bearers. The fruit is practically free from fungous diseases and is very rarely attacked by insects. Most of the muscadines ripen their fruit comparatively late in the season, after most other grapes are gone, and at the best season for wine making. Most other grapes grown in the South are quite subject to rot and insect injury, and the vines are short-lived.

MUSCADINES IN NORTH CAROLINA.

The Muscadine grapes are not equally well adapted to all parts of the State. They reach their greatest perfection in the Coastal Plain section. This, of course, is quite natural, as it is the home of most of these varieties. The climatic and soil conditions there are admirably suited to them.

They also do well in the Sand Hill region of the State. Even on the poor, white, dry sandy soils where few other plants thrive, these grapes reach a high degree of development.

They will grow quite well in the Lower Piedmont section, and especially on sandy soil, but the clusters are much smaller and the flavor inferior to those grown in the Coastal section. This is especially true on clay soils. For commercial purposes they should not be planted in this section.

Attempts to grow them in the Mountain and Upper Piedmont sections have usually resulted in failure. While the vines grow well in the Upper Piedmont, they very seldom bear fruit. They should not to be planted extensively at an elevation greater than six hundred to seven hundred feet.

MUSCADINES FOR MARKET.

These grapes are especially well suited to the family vineyard and for wine making, and may be marketed with some degree of success. Considerable objection has been raised against them for market purposes because of the small size of the clusters, but this objection does not always hold, as some of the varieties bear as many as fifteen to twenty-five berries to the cluster. Other things being equal, the clusters are much larger when grown on sandy soils than on clay soils. With some of the varieties the fruit shatters readily from the cluster as soon as ripe; with others the berries cling as tenaciously to the cluster as with any other variety of grapes.

UNFERMENTED GRAPE JUICE.

The question is often asked whether these grapes can be used successfully for making unfermented grape juice. Careful experiments by one of the largest wine manufacturers in the South show that some varieties of this species, especially the dark-fruited varieties, are well suited for this purpose. The writer knows of no reason why this should not become an important industry in the South. Although the Scuppernong does not seem to be so well suited for this purpose as the dark-fruited varieties, yet carefully conducted tests have shown that it may be successfully used.

SELF-STERILITY IN MUSCADINE GRAPES.

One of the most important questions connected with the growing of Muscadine grapes is whether or not they are self-sterile. At present this cannot be definitely answered, at least for all varieties; and more and better work will have to be done to determine this point. Certainly the same answer may not apply to the group as a whole. It is possible that some varieties will prove to be self-fertile and others self-sterile. Undoubtedly soil and climatic conditions have some influence on fertility in this group. Some of the varieties, notably the Scuppernong, appear to be more nearly self-sterile on the clay soils in the Piedmont section than on the sandy soils in the Coastal section. Some Scuppernong vines appear to be self-fertile and others self-sterile under apparently similar conditions.

The writer's work, while confined to only one season and one section of the State, gave decided results. A large number of flower clusters of the Scuppernong and Flowers were covered with paper bags before the flowers opened, and not a single fruit was produced. On the same Scuppernong vines other flower clusters were covered similarly, but later when the stigmas became receptive a flower cluster from a *male* vine was tied to each of these Scuppernong flower clusters. Three-fifths of these matured normal-size clusters of fruit.

BULLETIN 202 MAY, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

MANUFACTURE AND MARKETING OF COTTAGE CHEESE, SKIMMILK-BUTTERMILK AND ICE-CREAM.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

C. W. GOLD	Raleigh
E. M. KOONCE	Jacksonville
T. W. BLOUNT	Roper
D. A. TOMPKINS	Charlotte
J. T. ELLINGTON	Smithfield
W. E. DANIEL	Weldon
W. H. RAGAN	High Point
W. B. COOPER	Wilmington
M. B. STICKLEY	Concord
T. T. BALLENGER	Tryon
N. B. BROUGHTON	Raleigh
O. L. CLARK	Clarkton
EVERETT THOMPSON	Elizabeth City
R. H. RICKS	Rocky Mount
O. MAX GARDNER	Shelby
LOCKE CRAIG	Asheville

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant in Farm Crops
J. K. PLUMMER	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

PAGE.

Introduction 5
Preparation of Pure Cultures of Lactic Acid Bacteria 5
Making Cottage Cheese 6
  Souring the Skimmilk 6
  Heating the Curd 7
  Draining the Curd 7
  Grinding the Curd 8
  Yield and Selling Price of Cheese 8
Making Skimmilk-Buttermilk 8
  Souring the Skimmilk 8
  Churning 9
  Cooling 9
  Straining and Bottling 9
  Selling Price 9
Marketing Skimmilk-Buttermilk and Cottage Cheese 9
Selling Direct to Consumers 10
Food Value of Cottage Cheese and Skimmilk-Buttermilk 10
Serving Cottage Cheese 11
Marketing Ice-cream 11

MANUFACTURE AND MARKETING OF COTTAGE CHEESE, SKIMMILK-BUTTERMILK AND ICE-CREAM.

BY JOHN MICHELS, DAIRY HUSBANDMAN.

In making cottage cheese and buttermilk the first and most important essential is good flavor. Next in importance is uniformity of product. Both of these essentials can be obtained with certainty only by the use of pure cultures of lactic acid bacteria in souring the skimmilk.

The natural souring of milk is due to lactic acid bacteria, which act upon the milk sugar, changing a portion of it into lactic acid. Milk always contains these souring bacteria, but, as a rule, there are present also various other types which produce undesirable flavors. To suppress the undesirable types of bacteria, it is necessary to reinforce the lactic acid organisms by adding large quantities of them in pure form, that is, unmixed with other classes of bacteria. Commonly, such pure cultures of lactic acid bacteria are known as starters.

PREPARATION OF PURE CULTURES OF LACTIC ACID BACTERIA.

The cultures containing the lactic acid ferment are prepared commercially, and small samples, either in dry or liquid form, can be obtained from manufacturers at about seventy-five cents per bottle. The bottle thus obtained is emptied into a quart of pasteurized skimmilk, that is, skimmilk which has been kept at a temperature of about 170° F. for thirty minutes and then quickly cooled to about 70° F. As soon as the quart of skimmilk has thickened, which usually requires about twenty-four hours, it is ready for use.

In the process of heating, all of the active bacteria in the skimmilk have been destroyed, thus leaving a clean field for the development of the lactic acid bacteria added to it from the bottle.

The method of using the lactic acid bacteria is similar to the use of yeast in breadmaking. The original germs obtained from the manufacturer may be propagated for weeks by daily transferring a small amount of the thickened skimmilk to newly pasteurized skimmilk. As a rule, one pound of the thickened skimmilk will sour thirty to forty pounds of sweet pasteurized skimmilk in twenty-four hours at a temperature of 70° F.

Parenthetically, it may be stated that pure cultures of lactic acid bacteria (starters) are also frequently used in souring cream for buttermaking. Indeed, the highest quality of butter is not possible without their use.

MAKING COTTAGE CHEESE.

Hitherto no definite method has been employed in the making of cottage cheese, which, no doubt, is largely due to the fact that its manufacture has been almost entirely confined to the home. The method in common use consists essentially in placing curdled milk, either heated or unheated, in a linen or cotton cloth bag which is hung up in some convenient place to allow the curd to drain.

Where cheese is to be made on a commercial scale, this method has not been found satisfactory. After much experimentation we have succeeded in developing a method which has proven perfectly satisfactory in making cheese for city trade, and which it is felt can confidently be recommended for use by dairymen in general. The successive steps in this process are described in the paragraphs following.

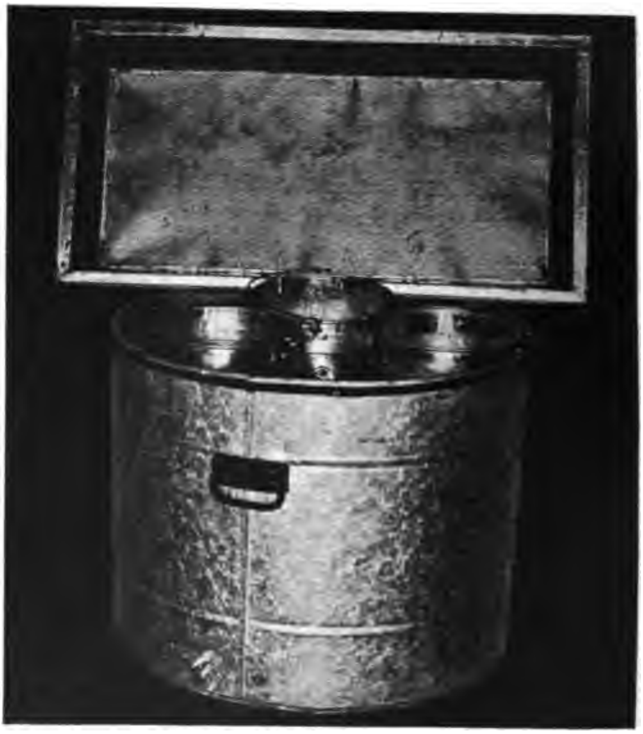


FIG. 1.—Strainer and Shotgun Cans in Water Tank.

Souring the Skimmilk.—Where from ten to twenty pounds of cheese are to be made at one time, the skimmilk is most satisfactorily soured in four to eight gallon shotgun cans which have a uniform diameter of from eight to ten inches. Enough pure culture of lactic acid ferment is added to sour the skimmilk in about three hours at a temperature of 100° F. As a rule, one gallon of culture to every four gallons of sweet skimmilk will accomplish the souring in the given time.

The culture should be vigorously stirred and then thoroughly mixed with the skimmilk. As soon as this has been done the cans containing the mixture are placed in a tank of water, as shown in Fig. 1. In heating the skimmilk to 100° F. the water in the tank should never exceed 110° F. The high temperature employed in souring the skimmilk has several advantages: (1) it hastens the souring process; (2) it causes the skimmilk to curdle with less acid, thus making a milder cheese; and (3) the curd may be stirred as soon as curdled without danger of diminishing the yield.

Where large quantities of cheese are to be made, the skimmilk should be soured in a common cream vat with an open end, which is usually used for adding ice to the water underneath. In the manufacture of cottage cheese, this open end is necessary in order to observe the temperature of the water used in heating the milk and curd.

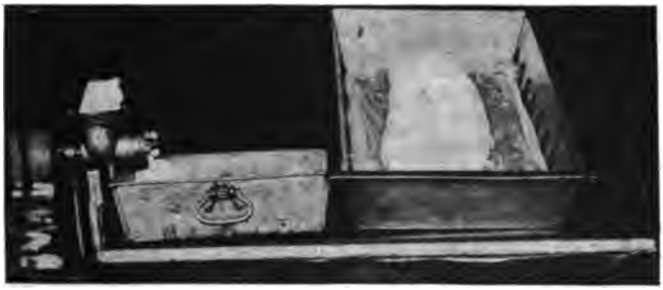


FIG. 2.—Curd in Strainer after pressing, and Curd Grinder.

Heating the Curd.—As soon as the skimmilk has thoroughly curdled, the curd should be raised to a temperature of 104° F. by heating the water surrounding the curd to about 115° F., and care should be taken never to heat it above 120° F. During the heating the curd should be constantly stirred with a stirrer consisting of a four-inch heavy tin disc attached to an iron rod. Where a cream vat is used, the stirring is done by hand. When the curd has reached a temperature of 104° F. the water surrounding it should be removed and the stirring continued for ten minutes more, after which it is ready to drain.

Draining the Curd.—This is best accomplished in a tin strainer with perforated sides and bottom like that shown in Figs. 1 and 2. The strainer should be of ample size to hold conveniently all the curd, to expedite drainage. A piece of cheese cloth should be spread over the strainer before receiving the curd. The latter must be hand-stirred as soon as it reaches the strainer, but the stirring should be done very carefully at the start to avoid loss by mashing the particles. Continue the operation until the curd is firm enough to prevent the particles from sticking together, which usually requires about five minutes. When proper firmness is reached, the curd is wrapped in the cloth strainer and squeezed with the hands until most of the whey has been removed. This operation requires only a few minutes, and care must be taken not to press the curd too hard. After pressing, the curd appears in a roll like that shown in Fig. 2.

Grinding the Curd.—Immediately after pressing, the curd is run through an ordinary meat grinder (see Fig. 2). The machine should be set for coarse grinding and should be large enough to enable one to complete the operation in a few minutes.*

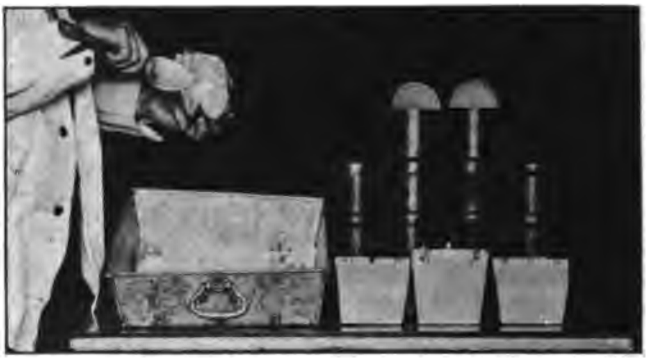


FIG. 3.—Cottage Cheese Packages and method of filling them.

The cheese is then put into packages by means of a large spoon, in the manner shown in Fig. 3. One-pound packages appear to be the most satisfactory for the average trade.

Yield and Selling Price of Cheese.—On an average it requires 7.1 pounds of skimmilk to make one pound of cottage cheese. The cheese was furnished grocers at ten cents per pound and was retailed by them at fifteen cents. We were able to dispose of twenty pounds per day at this price on the local market, a city in which the cheese had never been handled before.

MAKING SKIMMILK-BUTTERMILK.

Souring the Skimmilk.—As soon as the skimmilk leaves the separator, whole milk is added to it at the rate of one gallon to twenty gallons of skimmilk. This gives the mixture a fat content which approximates that of natural buttermilk. A large quantity of pure culture of lactic acid bacteria (starter) is next added and the temperature brought to 70° F. Enough culture is added to curdle the skimmilk in about six hours at the temperature mentioned. When a temperature above 70° F. is employed, there is a tendency for the skimmilk to "whey off" after it has curdled.

---

*After grinding the curd, it is soaked with sweet whole milk, using about one and one-half quarts for every ten gallons of skimmilk used.

Churning.—When thoroughly curdled, the skimmilk is placed in a churn and churned for forty minutes in the same way that cream is in making butter. The churning process thoroughly breaks up the curd clots, resulting in a smooth, thick liquid which cannot be distinguished from ordinary good buttermilk.

Cooling.—Immediately after the buttermilk leaves the churn, the temperature should be reduced below 50° F. to prevent further development of acidity. Ordinary milk and cream coolers with enlarged holes in the distributing receptacle will answer very satisfactorily.

Straining and Bottling.—After cooling, the buttermilk should be run through a strainer consisting of one thickness of cheese cloth to remove any unbroken curd clots. As soon as strained the buttermilk is bottled or put in tin cans holding from one to five gallons, after which it is placed in the refrigerator, where it should be held at a temperature of 40° to 45° F. until ready for delivery.

Selling Price.—The buttermilk made by us was sold to drug stores, lunch counters and hotels at five cents per quart in quart bottles and at fifteen cents per gallon in tin cans holding from one to five gallons. On an average, fifteen gallons were readily sold daily on the local market.

In the larger cities, buttermilk sells at a considerably higher price than given above. Thus, for example, the writer found that buttermilk during the past summer was furnished in bulk in Norfolk at from twenty-five to thirty cents per gallon. Considering both its food and tonic properties, buttermilk may be considered cheap at ten cents per quart.

MARKETING SKIMMILK-BUTTERMILK AND COTTAGE CHEESE.

What is said here with reference to this subject is a narration of our own experience in introducing these products in a city where they had never been used before.

In trying to sell skimmilk-buttermilk, it is necessary, in the first place, to explain that this product when made as described above is almost identical with the highest grade of natural buttermilk both in composition and physical properties, and therefore in palatability and wholesomeness. Indeed, it is not thought possible under average conditions to secure natural buttermilk of as uniform a quality or of as fine a flavor as can be obtained from skimmilk. When these facts are explained to dealers and consumers, any prejudice which might exist against this artificial product will gradually disappear.

The dealers in buttermilk were each furnished with an attractive display sign calling attention to the fact that the product was for sale at the particular place. Buttermilk is not commonly found at soda fountains, and unless conspicuous signs are posted at these places the public will not call for it. We believe that four-fifths of the buttermilk sold by us was due to these signs. Attention was also called to the product through the local press.

A similar arrangement was made with grocers in handling the cottage cheese. With small outlay for advertising in a city where these products had never been handled, we were soon able to dispose of over one hundred dollars worth per month.

Dealers should keep the cottage cheese and buttermilk in refrigerators, and neither of the products should be sold when more than two days old; the fresher the product the better.

SELLING DIRECT TO CONSUMERS.

It is recommended that dairymen supplying milk and cream to cities undertake the manufacture of cottage cheese and skimmilk-buttermilk, and to sell these products direct to consumers. This would insure getting the products fresh to the consumer every day, and would not entail any delivery charges, since the products would be delivered at the same time as the milk and cream. Furthermore, the profits of the middleman would be added to those of the dairymen. It is confidently believed that this would be the means of increasing the returns from dairies from ten to fifty per cent. The buttermilk could readily be disposed of at five cents per quart and the cottage cheese at from ten to fifteen cents per pound. Dairymen who could produce more of these products than could be disposed of to consumers direct could also supply them to the various local dealers in dairy products.

FOOD VALUE OF COTTAGE CHEESE AND SKIMMILK-BUTTERMILK.

These, when made as herein described, not only have a high food value, but possess tonic or medicinal qualities which are especially beneficial during warm weather. The food value of cottage cheese is approximately the same as that of beefsteak, pound for pound; and as for buttermilk, two quarts of this may be considered fully equal to one pound of beefsteak. Thus it will be seen that cottage cheese at fifteen cents per pound and buttermilk at seven cents per quart are no more expensive than steak at fifteen cents per pound.

SERVING COTTAGE CHEESE.

When the cheese is made according to the method given above, it may be served without any further treatment. Its palatability, however, may be improved by the addition of cream. Additional salt and some pepper is also preferred by some. Others prefer adding sugar or syrup. Caraway and sage are also sometimes used to flavor the cheese.

MARKETING ICE-CREAM.

Hardly any attempt has yet been made by cream producers living within driving distance of cities to convert their cream into ice-cream and sell this product direct to consumers. This is somewhat surprising, since the largest profits in the cream business have hitherto been made by what may be called the middleman, the city ice-cream manufacturer.

It is a vital matter with all producers to reach consumers direct wherever this is possible. Dairymen, for example, have long recognized the fact that the only way to get fancy prices for butter is to sell it direct to consumers. The same course must be pursued with respect to cream to get fancy prices for this product.

The essential thing in building up a good ice-cream trade is to make the best product possible. The market is glutted with cheap, inferior ice-cream, and the call now is for a high-grade product. Fortunately, the public is beginning to realize that there is positive danger in eating ice-cream made from stale milk or cream, and the public also seems to have begun to understand that the bulk of ice-cream is made with so-called thickeners, like gelatine, corn starch, tapioca, arrow root, and others. Many of the so-called ice-creams contain no cream whatever. The highest quality of ice-cream contains nothing but pure cream, sugar and flavoring.

BULLETIN 203 MAY, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

CORN WEEVILS AND OTHER GRAIN INSECTS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	LOCKE CRAIG	Asheville

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant in Farm Crops
J. K. PLUMMER	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

PAGE.

Angoumois grain moth (Fly weevil) (*illustrated*) 14
Annual loss due to grain insects 5
Bats, feeding on grain moths 22
Birds, feeding on grain insects 22
Black weevil, same as rice weevil (*illustrated*) 7
Cadelle, the (*illustrated*) 11
Carbon bisulphide, fumigation with 26
Corn weevils, so called 6
Cost of carbon bisulphide 27
Dark meal worm (*illustrated*) 10
Destructiveness of grain insects 5
Experiments in fumigation 25
Failure to kill grain insects by fumigation, cause of 27
Fly weevil, same as Angoumois grain moth (*illustrated*) 14

Fumigation experiments—

  with carbon bisulphide 26
  with sulphur 25
Grain attacked in the field 8. 17. 23
Grain beetles, several species 10
Grain moths 13
Granary weevil, similar to rice weevil 9
Importance of grain insects 5
Indian meal moth (*illustrated*) 17
Life-history knowledge, value of 6
Lime, as a repellent 25
Meal worms, several species 10
Meal snout moth (*illustrated*) 19
Mediterranean flour moth 18
Mites, feeding on grain insects 22
Methods of control in general 22
Naphthalene flakes, use of 25
Parasites, beneficial 22
Preventive measures, in general 23
Protection of corn by tight husk (*illustrated*) 24
Remedial measures, in general 22
Rice weevil (Black weevil) (*illustrated*) 7
Salt, as a repellent 25
Saw-toothed grain beetle (*illustrated*) 13
Spiders, beneficial 22
Sulphur fumes, for fumigation 25
True grain weevils 6
Work of weevils in old corn (*illustrated*) 9
Yellow meal worm 11

CORN WEEVILS AND OTHER GRAIN INSECTS.

BY R. I. SMITH, ENTOMOLOGIST.

Like practically all agricultural products, corn and other grains are subject to the attack of numerous destructive insects, some of them commencing their depredations in the ripening grain in the fields, while others abide solely in the barns, storerooms or cribs where the grain is stored. Farmers of North Carolina and, in fact, of all the Southern States, expect a greater or less number of weevils or other insects to be in their granaries each spring, and consider it fortunate when only a few are present. As a general rule, the injury inflicted to the grain is underestimated, and the loss in total weight and feeding value is accepted as an annoying but unavoidable condition.

The actual loss occasioned by insects in whole grain and the various stock foods cannot be accurately estimated; the grain is not only reduced in weight and consequent selling value, but is often rendered wholly unfit for human food and less valuable as food for live stock.

As an example of the extent of the injury caused by grain insects, a consideration of the value of the grain crop will be of interest. The corn crop for North Carolina in 1908 was valued at $39,631,000 and the wheat crop at $6,078,000, a combined total of $45,709,000. Since there are no statistics to show the actual annual injury caused by insects, it may be conservatively estimated at five per cent, which is lower than the actual per cent of damage reported for certain other Southern States in previous years. Five per cent of the total is $2,285,450, an amount representing the possible annual damage by grain insects to corn and wheat crops alone in North Carolina.

The list of really injurious species of insects attacking stored grain, and the principal feed stuffs manufactured therefrom, number twenty and upwards. There are two true weevils and at least one dozen other forms known as beetles in their adult stage, while we find six common and injurious species whose parents are moths. Ten of the most important and conspicuous of this number are described in the pages following. The principal damage to whole grains is caused by the rice or black weevil and the angoumois grain moth or fly weevil, but the others mentioned are frequently present in destructive numbers. In eastern North Carolina the black weevil probably predominates, but in the western section the fly weevil holds first position. In many localities these two species and others of less importance are found working together, sometimes actually occurring in the same kernels of corn.

For the reader who is not familiar with the grain insects, the illustrations (original photographs by the author) and statements concerning the life-history of each will help to show the importance of this subject. It is not always realized how rapidly these insects—the true weevil, for example—may increase in numbers under favorable conditions, nor is it known by all that grain may become infested in the field before harvest. With species that produce only one generation annually, it is not realized how important is the matter of killing them in the larval and pupal stages, an example being the dark meal worm. These and other points given under the discussion of each species in the following pages are necessary for an intelligent understanding of the grain insect problem.

The presence of insects in grains, meals and food stuffs is not easily prevented, nor is it an easy matter to kill them after once gaining a foothold, but certain preventive and remedial measures may be adopted to avoid a portion, at least, of the annual loss. A portion of this bulletin is devoted to the discussion of the best known and most effective control measures. Attention is called especially to the carbon bisulphide fumigation treatment, as this has for many years been principally recommended for destroying grain insects. The writer's recent experiments show conclusively that fumigation with this substance cannot give satisfactory returns when employed under ordinary farm conditions where grain is stored in cribs or rooms that cannot be made sufficiently tight to hold the poisonous fumes long enough to kill weevils.

The purpose of this Bulletin is partly to give farmers a more accurate knowledge of the various grain pests, and to caution them to use preventive measures wherever possible, and partly to explain the limitations in the use of carbon bisulphide for fumigation of infested grain.

THE GRAIN WEEVILS.

The popular name for all insects working in stored grain is weevil; but restricting ourselves to the correct meaning of the term, there are only two true grain weevils. These are the rice weevil and granary weevil, two closely related species, which in the mature stage are small dark-colored beetles possessing a snout or proboscis about one-third as long as the body, and belong among a group of snout beetles that include such familiar forms as strawberry weevils, corn bill-bugs, plum curculio, acorn weevils, and many others. The grain pest known to farmers as the fly weevil, a species fully as destructive as the true weevils, should be placed in a different class, because of the mature form being a small moth which does no damage other than to lay eggs; and the same may be said of all the grain pests that develop into moths. The remaining grain insects, which are different forms of beetles in the mature stage, do not belong to the group of snout beetles, and are not properly called weevils.

THE RICE WEEVIL (BLACK WEEVIL) (*Calandra oryzæ,* Linn).

The name corn weevil or black weevil is usually applied to this species, although its original name is rice weevil, so called because of its being first discovered in that grain. The former names are also applied to a near relative, the granary weevil; hence we should preserve the title rice weevil to make this species distinctive. India is thought to be its native home, but the species may now be found in nearly every grain-producing country of the world, and is particularly abundant in the Southern States, but is less numerous farther North.

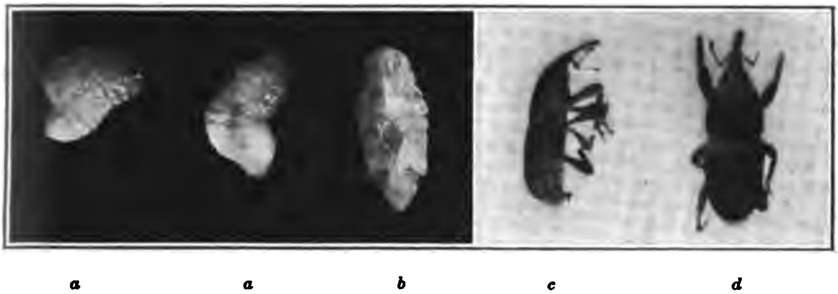


FIG. 1.—The Rice Weevil or Black Weevil; *a*, full-grown larvæ; *b*, pupa from beneath; *c* and *d*, adults—about five times natural size.

Injury is caused by the adult beetles eating into grain for food and shelter, as well as by the larvæ that feed inside the kernels. Small grains like wheat and rice furnish food for only a single larva in each kernel, but in corn three or four may mature. It has been estimated that one pair will, in the course of a year, produce over 6,000 descendants. The effect on the grain is to reduce the weight materially, and consequently its selling value, and renders the grain unfit for human consumption.

DESCRIPTION AND LIFE-HISTORY.

The mature weevils (Fig. 1, *c* and *d*) average to measure about one-sixth inch, including the snout, which is about one-third the length of the body. The general appearance is dark reddish-brown, but individuals vary from a light brown to nearly black; the thorax presents a network of minute round punctures; the wing covers or first pair of wings bear a more or less distinct red spot near the base and tip of each wing, while the whole surface bears small punctures arranged in longitudinal rows. Underneath these, the second pair of wings are membraneous and well developed, enabling the beetles to fly to fields remote from the granaries. The snout bears a pair of elbowed antennæ (feelers) and terminates in strong biting jaws.

The larva (Fig. 1, *a*) is white, fleshy and robust, possessing strong, horny, brown jaws. Legs being unnecessary, are not present. When fully grown the larva transforms to a pupa (Fig. 1, *b*) in its burrow, in which stage it shows the general size and outline of the future beetle, but is transparent and white in color.

The eggs are small and white and are laid in minute punctures made in the grain by the jaws of the female weevil. The tiny larva when just hatched commences at once to gnaw toward the center or makes a channel for some distance just under the skin of the grain. The channel is always filled with a fine powder, quite different in appearance from the pellet-like excrement left by the larvæ of the angoumois grain moth. When nearly grown the larva provides for the easy escape of the mature weevil by leaving only a thin skin over the burrow, and then quietly transforms to a pupa, which in time changes to the mature weevil.

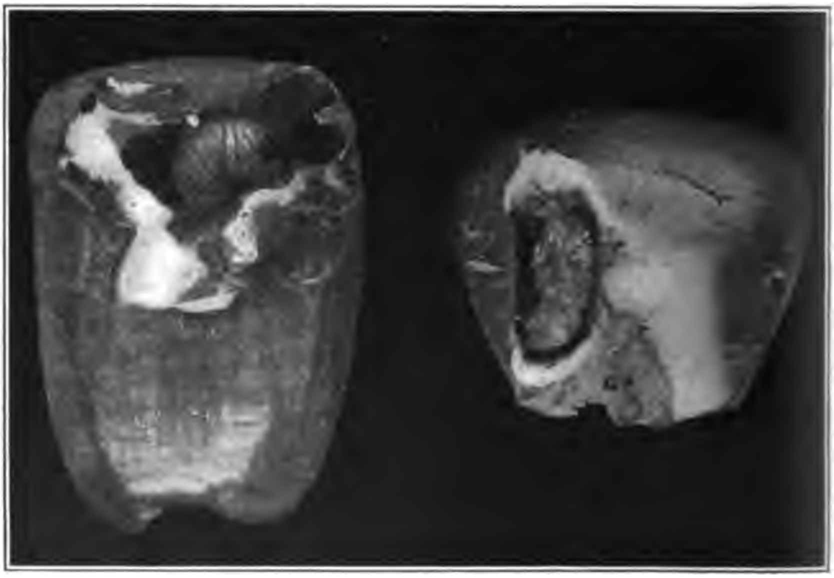


FIG. 2.—The Rice Weevil larva and pupa *in situ* in corn; *a*, larva; *b*, pupa; both enlarged five times.

Four or five generations mature each year. At Raleigh the writer observed adult weevils laying eggs on ripening corn in the field, on September 12, 1908; he also found a few small larvæ. From an ear of corn collected on this date adult weevils emerged on October 17, showing that in this instance the eggs must have been laid early in September, or possibly in August, because it is known that the period from egg to adult is about six weeks in warm weather. In addition to the weevils that fly to the fields and attack the ripening grain, many continue to breed all summer in the granaries where food is obtainable, and whenever infested grain is kept until the new crop is housed, the weevils are furnished ideal conditions for rapid development. It is impossible to prevent grain from becoming infested in the field, but the farmer can see that no weevils are present in the barns or granaries when the crop is housed. The practice of keeping corn the year round and sometimes putting new corn on top of the remains of the previous year's crop cannot be too strongly condemned.

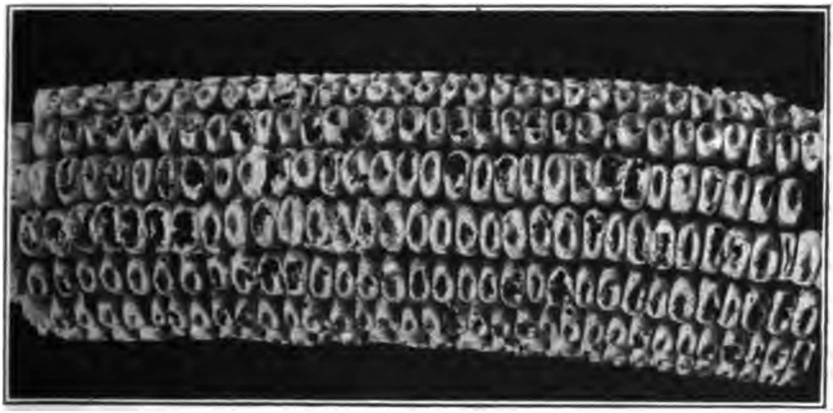


FIG. 3.—Work of Rice Weevils and the Cadelle in two-year-old corn.

Wheat, oats, rice and other grains serve as food for the rice weevil, and may be infested in the field at about the time the kernels are ripening. With corn it has frequently been observed that the ears having a tight husk are seldom attacked by weevils, but we are confronted with the fact that the corn ear-worm (*Alabama argillacea*) frequently makes entrance and exit holes through the husk of the most perfect ears, and by means of these openings the adult weevils enter ears that would otherwise be inaccessible to them.

The general discussion of preventive and remedial measures is given on pages 22 to 27.

THE GRANARY WEEVIL (*Calandra granaria,* Linn).

In general size, appearance and feeding habits the granary weevil is almost identical with the rice weevil. It may be distinguished, however, by its lack of membraneous wings, consequently being unable to fly, and by the thorax being sparsely and longitudinally punctured. It is also generally somewhat lighter in color than the preceding species. It requires only passing mention here, for the rice weevil far surpasses it in numbers and destructiveness in the Southern States. Owing to its lack of wings, the granary weevil remains in the barn and corn cribs; hence, where proper precautions are taken to feed or remove all infested corn each fall before the new crop is housed, this species can never become abundant like the preceding one. The granary weevil infests wheat, corn, barley and other grains, but is generally considered as a corn weevil.

GRAIN BEETLES AND MEAL WORMS.

There are nearly a dozen species of beetles that attack grain, meal, bran, middlings, and many food products, and often work side by side with the true weevils. The cadelle, which is described, is nearly always found in the barns and grain rooms of the Southern States, and several smaller species of grain beetles are equally abundant, but do less damage because of their small size. The species that the writer has found most abundant are the following:

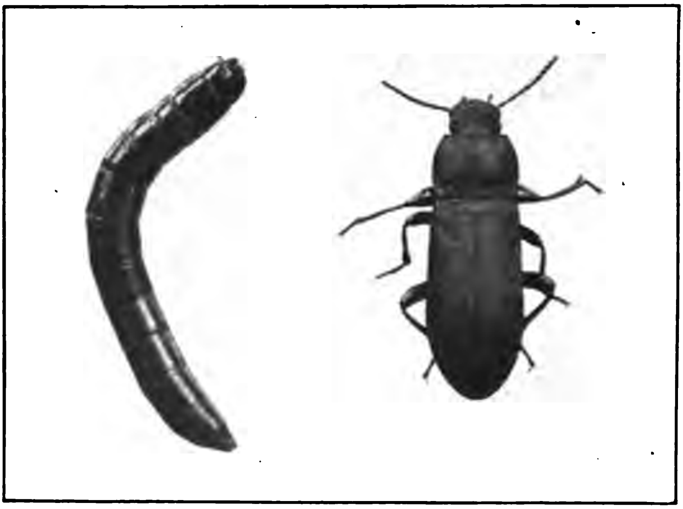


Fig. 4.—Dark Meal Worm and parent beetle. Two and one-half times natural size.

The Dark Meal Worm (*Tenebrio obscurus,* Linn).

This species, illustrated in Fig. 4, feeds mainly in meal, bran and other stock feeds, but may be found at times in whole grains. They often become abundant in grain bins that are not often entirely emptied, a good illustration having come under the writer's observation recently, in a barn at West Raleigh where hundreds of the beetles were found during the first and second weeks of May.

There is only one generation each year. The beetles normally appear about the last of April, in this section, and soon deposit small, white, bean-shaped eggs in whatever food is at hand. The eggs hatch in two weeks into small delicate larvæ, which increase rapidly in size, and are said to become fully grown in about three months.

The worms, when grown, are darkish brown in color, with a smooth waxy skin, resembling a wireworm. They attain a length of about an inch and live in this stage without much change during the winter, transforming in spring to whitish pupæ and eventually to mature beetles. These are dull black in color and average a little less than three-quarters of an inch in length. The beetles are nocturnal in habits, scampering rapidly out of sight when suddenly exposed by the opening of a grain box.

The meal worms frequently breed in the bottom of grain bins or in corners where meal, flour or other refuse material has accumulated, but as they develop only one generation a year, thorough cleaning-out of all infested material during July or August, after the eggs are laid, will suffice to control them.

THE YELLOW MEAL WORM (*Tenebrio molitor,* Linn).

Differing from the preceding species in color, but not much in size or habits, the yellow meal worm is frequently found in stock foods, flour mills, bakeries, feed rooms and similar places. The worms are yellow, shading to darker toward each end and near the articulation of each joint, but in other respects do not differ from the dark meal worm. The adult beetles of this species are blackish and shining, instead of dull black, and have certain other points of difference, but their habits are the same as the parents of the dark meal worm.

THE CADELLE (*Tenebriodes mauritanicus,* Linn).

A widely distributed species occurring in all manner of prepared food products, as well as in grain, meal and other stock foods, is illustrated in Fig. 5. The larvæ was given the name "cadelle" in France many years ago, when it was classed as a meal worm, and in recent years some authorities have claimed that this species is predaceous and carnivorous rather than granivorous, but the writer has observed that it possesses both habits. Chittenden states that he has proved it to be both a feeder on grain and other insects. Consequently the cadelle represents an insect that is both beneficial and injurious. In old corn it is particularly destructive, and in my opinion the injury caused is greater than its beneficial work by destroying other grain insects. It is not uncommon to find cadelle larvæ feeding in grain from which weevils have emerged.

The parent beetle (Fig. 5) is elongate, flattened, and nearly black, measuring about one-third of an inch in length. The larva (Fig. 5) measures nearly three-fourths of an inch when fully grown, its general coloring being whitish, with the head and anal segments dark brown, and the three thoracic segments marked with brown. The body is fleshy and tapers gradually toward the head.

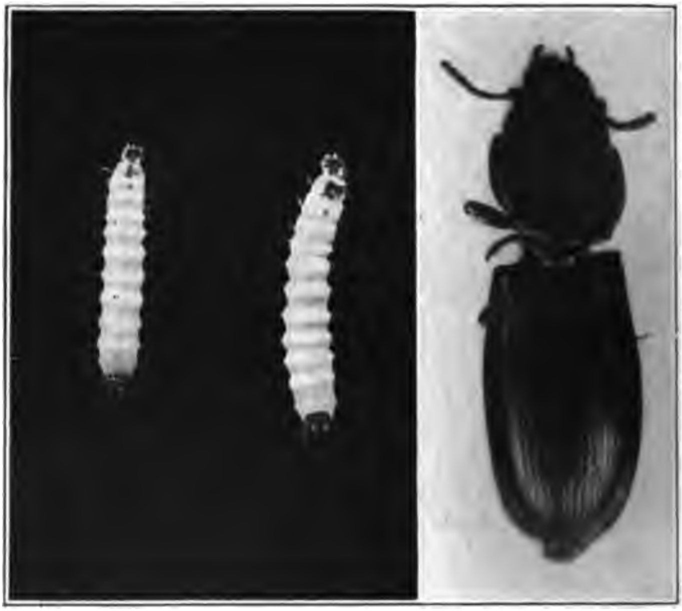


FIG. 5.—The Cadelle; full-grown larvæ twice natural size; parent beetle seven times natural size.

Both the larva and adult feed in the grain, frequently changing their positions, perhaps in search of weevil larvæ, but most assuredly they cause much injury and should be dealt with like any other grain insect.

Only one generation is produced annually, which is very fortunate, as otherwise the species might prove one of our worst grain insects. Recent experiments by the writer have shown that the beetles are more difficult to kill by fumigation with carbon bisulphide than the adult corn weevil, although the larvæ are quite readily destroyed by this treatment.

THE SAW-TOOTH GRAIN BEETLE (*Silvanus surinamensis,* Linn).

This is one of the smallest, but most common, of the insects attacking grain and nearly all food stuffs. Its small size enables it to penetrate the smallest cracks, and its taste for all kinds of food causes it to be found in granaries, storerooms, groceries, pantries and bakeries, even feeding on red pepper. As a grain pest this species does not actually devour enough to render its presence a source of great loss, but it is nevertheless a great nuisance, and infested food stuffs may be rendered unfit for consumption. Both the larvæ and adults have the habit of eating holes in paper bags in search of food.

The mature beetle (Fig. 6, *b*) is only about one-tenth inch in length, much flattened and chocolate-brown in color. The thorax bears six minute points or teeth on each side, which may be seen in the illustration.

The larva (Fig. 6, *a*) is a slender white worm with darker markings, and is very active, moving frequently from one place to another.

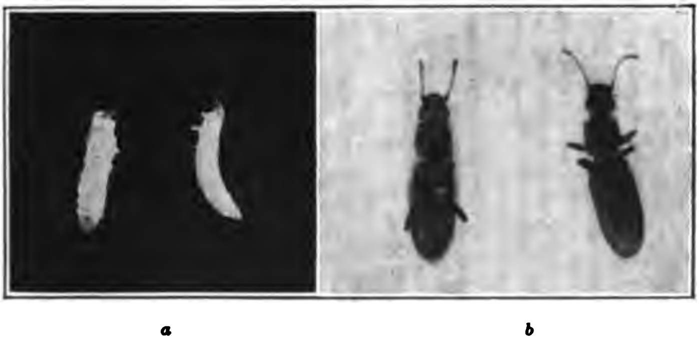


FIG. 6.—The Saw-tooth Grain Beetle; *a*, nearly grown larvæ; *b*, parent beetles—both greatly enlarged.

There are said to be six or seven generations annually, the entire life cycle being covered in twenty-four days in midsummer.

The writer's experiments have shown that these beetles are killed by carbon bisulphide fumes a little more easily than are the corn weevils or other grain beetles mentioned above.

GRAIN AND MEAL MOTHS.

We now come to grain insects of which the parents are moths, and among them are found some very destructive species. Only one, the larvæ of the angoumois grain moth, develops entirely in the kernels of grain, either wheat, corn, barley or other cereals, while the remainder have the habit of passing from one grain to another, marking their progress by a silken tube or web, or working their way through meal, bran or whatever material they occur in, transforming the same into a worthless webby mass. Owing to this habit the meal worms cause damage all out of proportion to the amount of food they actually consume.

In point of importance the angoumois grain moth should stand next to the rice weevil—in some localities, in fact, greatly outstripping it in numbers.

The Angoumois Grain Moth (Fly Weevil)
(*Sitotroga cerealella*, Ol.).

The Southern farmer generally applies the term "fly weevil" to this species to distinguish it from the rice or black weevil, but the term is hardly appropriate, because the adult flying moth is simply the parent form of the worm that feeds in the grain. This species does not attack meal or food products, but lives in the whole grain, a single kernel of corn often furnishing food for two or three larvæ. The characteristic appearance of an infested ear of corn, as sometimes found in the field during October or November, is shown in Fig. 7. Fig. 8 shows an ear from which several generations of moths have emerged, such specimens being frequently found in two-year-old corn.

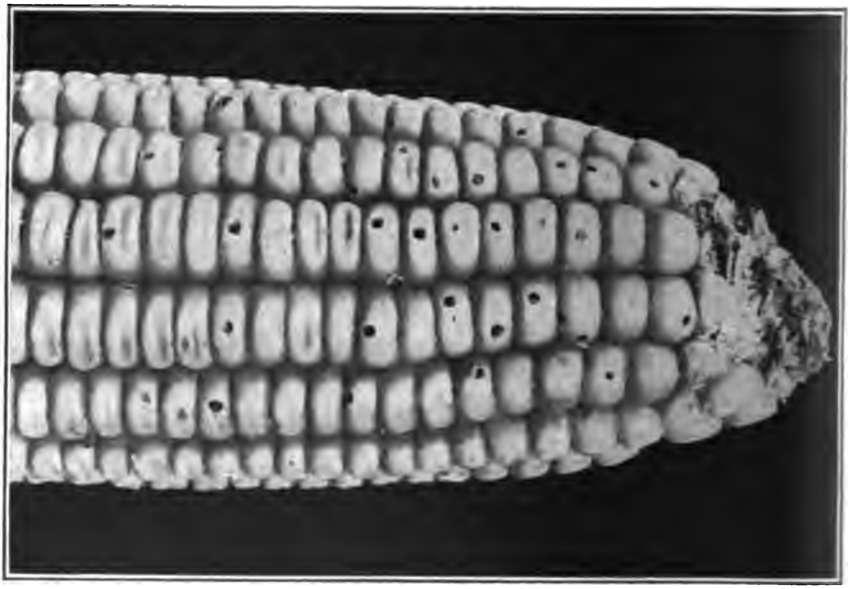


Fig. 7.—Showing the work of the Angoumois Grain Moth, as often seen in October—slightly enlarged.

The moths are seen in Fig. 9, the male always being of smaller size. In color they are light grayish-brown, with lines of black, and

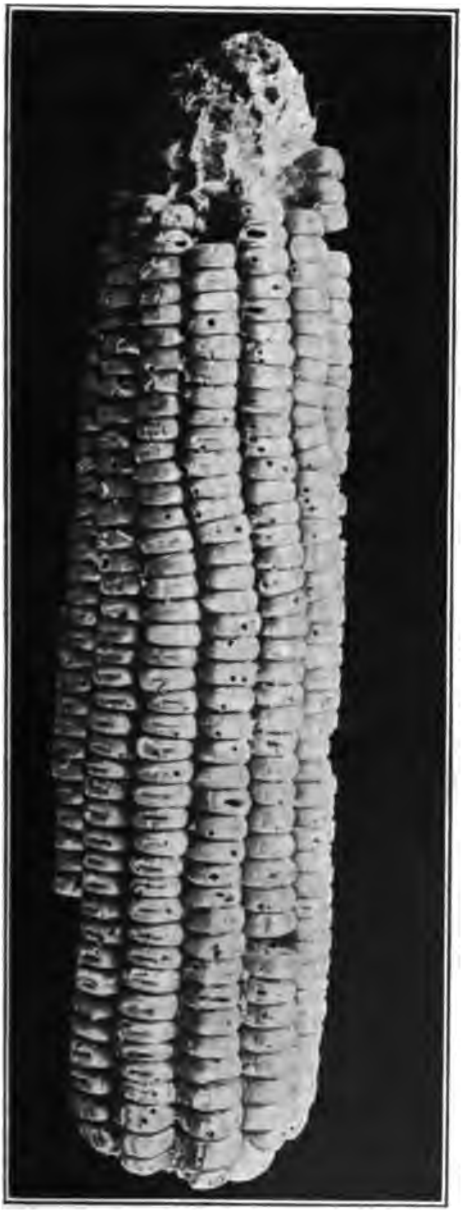


Fig. 8.—Ear of corn from which several generations of the Angoumois Grain Moth have emerged—slightly reduced.

measure across the expanded fore wings a little over one-half inch. The front wings bear a fringe of long hairs on the anal edge, and the hind wings bear a continuous border of the same. The moths are very delicate, easily crushed and readily killed by poisonous fumes.

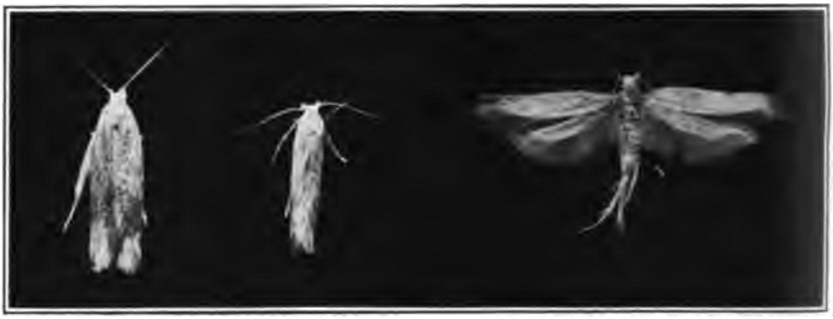


Fig. 9.—The Angoumois Grain Moth; *a*, female; *b*, male; *c*, male with wings expanded—all two and one-half times natural size.

The larva (Fig. 10, *b*) is white, distinctly segmented and attains a length of about one-quarter of an inch. The jaws are brown and horny. When grown the larva transforms to a light-brown pupa (Fig. 10, *c*) in its feeding place, but provides beforehand for the escape of the adult by leaving over its burrow only a thin skin of the grain, through which the moth easily manages to escape.

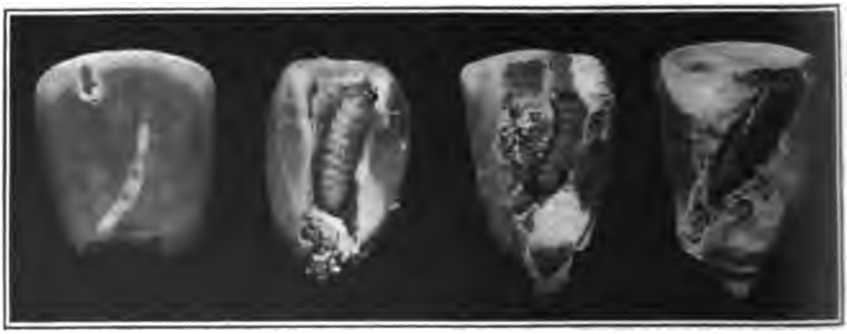


Fig. 10.—The Angoumois Grain Moth; *a*, natural appearance of infested kernel; *b*, larvæ in natural position; *c*, pupa, same—all two and one-half times natural size.

The eggs, deposited singly or in clusters, are at first white, but soon turn reddish and hatch in four to ten days, depending on the temperature. Each female lays from sixty to ninety eggs. The larva when hatched is active and soon penetrates the grain, leaving an almost invisible opening. In about three weeks the larva is fully grown and transforms to the pupa stage. Both larva and pupa are shown *in situ* in Fig. 10 in partially opening kernels of corn.

During the year five or six generations of moths may be produced. Farmers commonly remark that grain becomes infested in spring when large numbers of moths are seen flying in the granaries—thus gaining for them the name "fly weevil"; but in reality the grain is generally first infested in the field. At West Raleigh the writer found, in 1908, that many moths had matured and escaped from ripening corn in the field on September 10. Two days later an ear of corn was taken and placed in a glass jar, and by September 27 thirty-four moths had emerged. From this it is seen that the first brood in the field must mature here as early as the beginning of September, and it may be that the writer missed the first brood. In any event there must be two full broods and probably three during the summer and fall, the winter being passed in the larval stage. In spring the moths commence to emerge in April, and earlier in the warmer sections of the South, and succeeding generations may mature about every six weeks.

Grain in the field is evidently not infested until nearly grown, or in such condition that the first moths mature about when the grain is ripening. It is certainly a bad practice to leave corn cut and stacked in the field during the fall months, for in such condition more ears are exposed to egg deposition than would be if the corn were stored in the grain cribs. The moths will not be present in the granaries during the fall months if proper precautions have been taken to get rid of all infested grain of the previous year's growth.

THE INDIAN MEAL MOTH (*Plodia interpunctella,* Hbn.).

This species is not a serious grain pest, but the writer has reared a considerable number of the moths from corn infested principally with the angoumois grain moth. The usual food of the Indian meal moth larva is said to be dried fruit, seeds, nuts, roots and condiments as well as meal and grain products.

The parent moth is shown in Fig. 11. The fore wings expand a little over one-half inch, and may be described as having the inner third dirty whitish-gray, and the outer two-thirds reddish-brown. The hind wings are of a uniform light-gray color bordered with a fringe of hairs. When seen in houses they are frequently mistaken for clothes moths.

The larva or caterpillar reaches a size of about three-eighths of an inch, and unlike the species just mentioned, does not live in a single kernel of grain. On the other hand, they pass from one place to another, spinning large quantities of silk and fastening the particles of food together. It is claimed that they have a special fondness for the embryo of wheat, one caterpillar often ruining dozens of kernels for seed or food purposes. The entire life cycle may be passed, from egg to adult, in five weeks in warm weather; hence several generations a year may be expected.

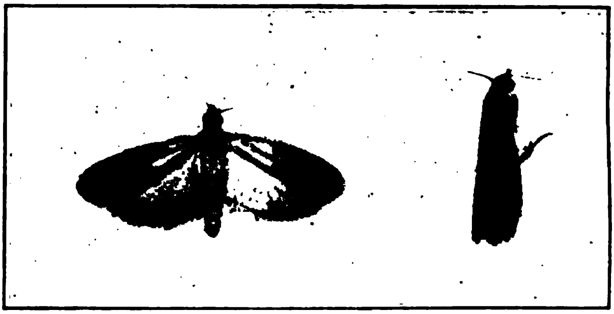


FIG. 11.—The Indian Meal Moth, enlarged two and one-half times.

The parent moths are easily killed by poisonous fumes and the larvæ are more easily killed than those of the angoumois grain moth or corn weevil, which live entirely within the grain.

THE MEDITERRANEAN FLOUR MOTH (*Ephestia kuehniella*, Zell).

As a pest in stored grain this species is of slight importance, but it has no equal in destructiveness in flour mills, and in the absence of its favorite food, such as flour or meal, it will attack grain and flourishes on bran and cereal foods. The writer has bred this species from cotton-seed meal. The history of this insect commenced in 1877, when it was discovered in a flour mill in Germany and later invaded Belgium and Holland. In 1892 it was reported as occurring in mills in Canada and during 1895 in New York and Pennsylvania.

The moth is described as having a wing expanse of a little less than an inch, the fore wings being blackish-gray with transverse black markings, the hind wings being dirty whitish color.

The larval stage is really a caterpillar that reaches a length of one-half inch and is pink in color. Its full growth is attained in about forty days, after which it changes to a reddish-brown pupa in a silken cocoon.

The caterpillars have the habit of spinning silken tubes wherever they travel, feeding from the mouth of the tube, and it is this habit that renders them so injurious. Infested flour or meal becomes matted together and lumpy, clogging the machinery in mills and rendering the material in which they feed unfit for human consumption. When such infested material is discovered it should be destroyed immediately, and wherever mills are found infested, prompt measures should be taken to exclude the pest by destruction of the insects in infested material, by thorough cleaning and by fumigation. Afterward, a strict inspection and quarantine should be established to prevent the entrance of infested material. Farmers need not fear this pest, but millers should be on the lookout for its appearance.

THE MEAL SNOUT MOTH (*Pyralis farinalis,* Linn).

This is a larger and in many respects more conspicuous species than the ones already described. The writer's attention was attracted to this insect in March, 1909, by finding hundreds of the worms and pupæ in grain bins in one of the Experiment Station buildings. These bins had been in use for a number of years, and it seems that they have not often been entirely emptied, and it is just that condition, where the bottom of grain bins are never reached, that induces the rapid increase of all kinds of meal worms. The infestation thus found furnished good material for a fumigation experiment, which will be mentioned, and for securing specimens in all stages.

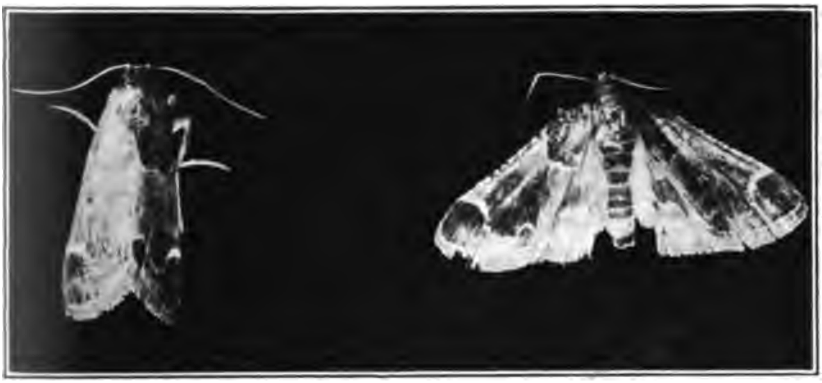


FIG. 12.—The Meal Snout Moth, enlarged two and one-fourth times.

The parent moths are illustrated in Fig. 12 nearly two and one-half times natural size. They measured across the expanded wings from seven-eighths to one and one-eighth inches, and are considerably larger than described by most writers. The females are always larger than the males. The coloring is light or dark brown with reddish reflections, and the wings are crossed by wavy white lines. The moths are nocturnal in their habits and fly quickly when disturbed.

The caterpillars are rather slender and average to measure one inch in length; the head is shiny brown; the first thoracic segment and the anal segments are distinctly orange-yellow in color. In Fig. 13, *a,* is shown its general appearance. Its feeding habits are somewhat like the preceding species, a delicate silken tube being spun as it feeds. The feeding tube (Fig. 14) taken from a bin of bran, and showing the adhering particles, is constructed out of sticky, silken threads which are always covered with whatever food the worms are working in. whether it be meal, bran, whole wheat or other grain.

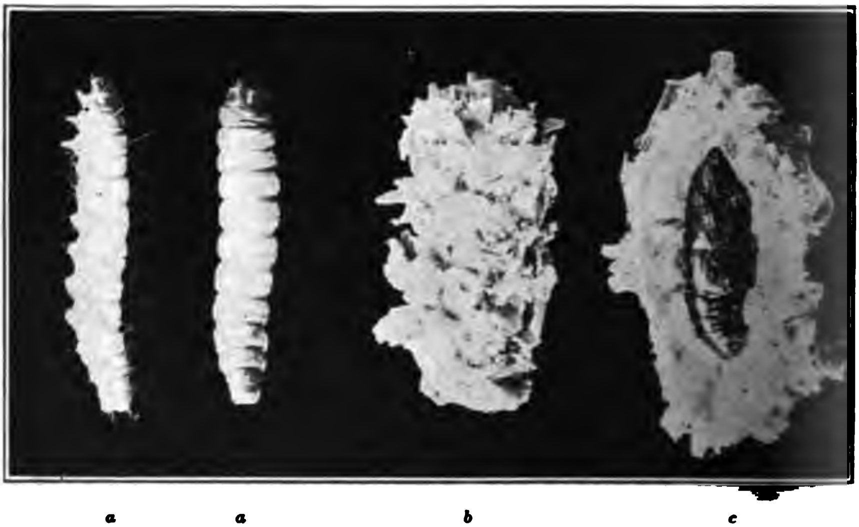


FIG. 13.—The Meal Snout Moth; *a*, larvæ; *b*, cocoon; *c*, pupa in an opened cocoon—all two and one-fourth times natural size.

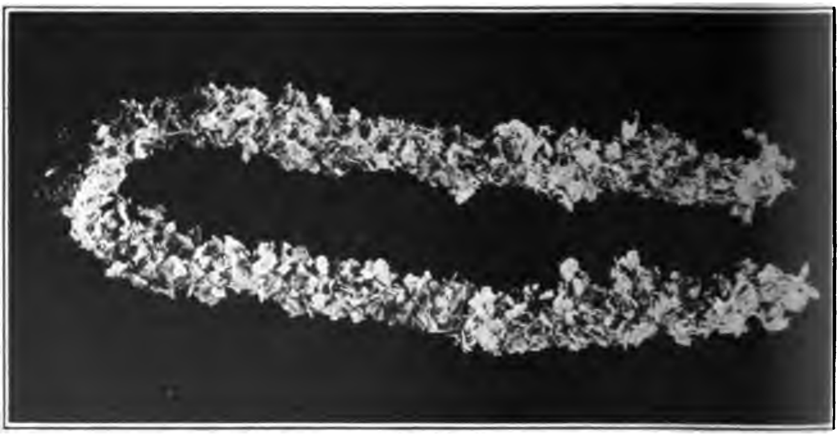


FIG. 14.—Feeding Tube made in bran by the larva of the Meal Snout Moth—slightly reduced.

The pupa stage is assumed in a tough silken cocoon covered with particles of food, as illustrated at Fig. 13, *b,* an open cocoon being shown at *c*. The pupa is light reddish-brown and of the form illustrated. Fig. 15 shows a small section of a bran bin covered with meal-worm cocoons, which were equally numerous on all sides.

Concerning the life-history, this species passes the cold months in the larval stage, and at West Raleigh the first moths emerged this year on April 20. Three or four generations annually are credited to this insect.

As a grain pest the meal snout moth is not of great importance. Among its various foods may be mentioned hay, straw, seeds, dried plants, all grains and the products made therefrom, and masses of refuse vegetable matter, such as potatoes. Evidently this insect flourishes best in moist surroundings and is not liable to thrive in material stored in a dry, clean place.

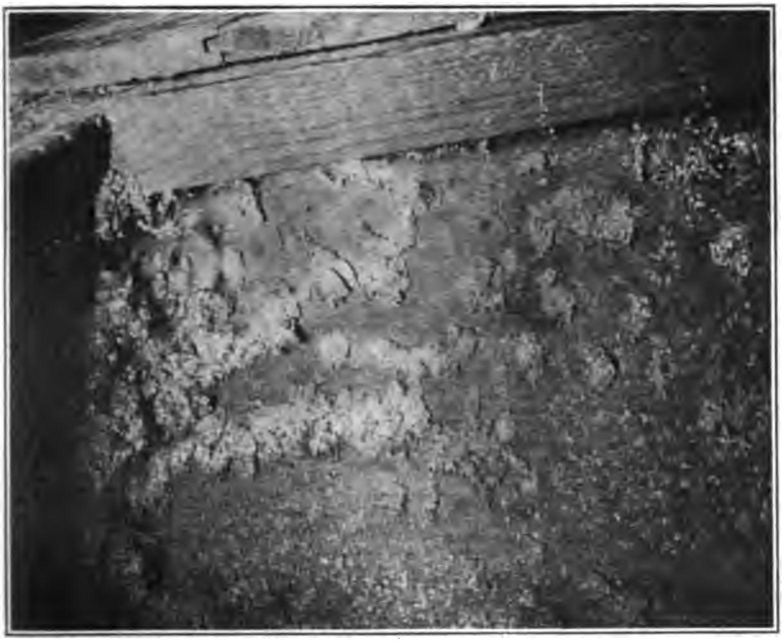


Fig. 15.—Showing cocoons of the Meal Snout Moth on the side of a grain bin in which bran was kept.

As remedial measures the destruction of infested material and cleaning-out of places where the worms are discovered are by far the best. Fumigation with carbon bisulphide might be effective against the caterpillars in a perfectly tight box or bin, but it is doubtful if the pupa in their cocoons can be killed by any ordinary strength. In the bran bin in which the worms were discovered (see Fig. 15), as already mentioned, carbon bisulphide was used this year at the rate of five, ten, fifteen and twenty pounds, respectively, per thousand cubic feet, on April 7, 10, 14, and 15, and after the fourth treatment some of the pupæ were alive and have since transformed to moths. This bin was apparently air-tight except for a crack on the hinged edge of the cover. The details of the experiment need not be discussed here, except to explain that the first and second treatments killed only a small per cent of worms, the third killed nearly all, and the fourth would have been considered a perfect treatment had not a few moths issued later.

PARASITES AND PREDACEOUS ENEMIES.

Nature provides in the form of parasites a means for preventing the unlimited increase of nearly all injurious insects. Even the larval stages of insects in grain are killed frequently by these beneficial parasites, which are small black flies in the adult stage. Two or three species of chalcis flies have been bred from the larvæ of corn weevils and the angoumois grain moth. The other grain moths and meal worms are known to have parasitic enemies whose work in the aggregate is a considerable help toward controlling grain insects. It is not uncommon to find larvæ and pupæ of the angoumois grain moth that have been killed by parasites. Farmers can easily verify these statements by enclosing some weevil-infested grain in a glass jar and observe the minute black flies that emerge.

Among the predaceous enemies may be mentioned mites, spiders, insects of nocturnal habits, birds and bats.

The mites are diminutive, white, spider-like animals, that prey on many species of grain insects. Spiders occurring in the granaries and mills spin webs that entrap many of the grain moths, while bats hover around the grain bins and barns for the purpose of feeding on the moths. The cadelle, already mentioned, feeds on other grain insects, and probably does considerable good in this respect, but its presence is not desirable, as it also does much injury.

GENERAL CONTROL MEASURES.

These may be either preventive or remedial, or a combination of both, as it might properly be termed, when such measures are taken as tend to kill the adult parent forms, which, in many cases, do no damage aside from laying eggs for another generation. Under the head of preventive measures, several things may be mentioned, but no one alone will solve the problem, and the following discussion is given mainly as a suggestion based on the known habits of these insects. Fumigation with carbon bisulphide has in the past been the chief remedy, and is yet to a certain extent, but the reader is requested to note the results of recent experiments that show how difficult it is to confine the poisonous fumes in ordinary granaries long enough to kill the various insects that may be present. The old adage "an ounce of prevention is worth a pound of cure" is just as applicable in this connection as it is in troubles of other nature.

PREVENTIVE MEASURES.

Grain first becomes infested through one of two sources: (1) the insects may attack the ripening grain in the field, and (2) the insect may live continuously in barns and granaries ready to commence work in the newly harvested crop. The second source of infestation is more easily prevented than the first.

Field Infestation.—Some species like the rice weevil, angoumois grain moth, saw-tooth grain beetle and a few other small grain beetles are usually found in ripening grain, particularly corn. As a general rule, grain is partially matured, or at least nearly grown, before it is attacked by insects, which of course come from the places in which the grain is stored during the winter. As it cannot be hoped to kill all the insects in stored grains and thus prevent their going to the fields, an effort must be made to prevent them from getting back again in the new grain. Small cereals like wheat and rye should be threshed as soon as dry enough, as that process will kill many of the adult insects and dislodge the eggs. The adult angoumois grain moth is easily crushed and the threshing and handling of the grain destroys many of them. After it is threshed the grain should be stored in tight bins or in sacks, the latter being preferable, because the moths that mature will die without escaping. Whenever the grain, if infested, can be fumigated in practically air-tight boxes or receptacles, carbon bisulphide should be used when the grain is first housed. The practice of storing grain in large bulk is to be commended, as a protection from weevils or grain moths, for then only the surface layers are exposed. This is in direct accord with the recommendation that grain should not be cut and stacked in the field for several months. Such practice tends to allow the insects to infest all the grain more readily than if the same were stored in a large bulk.

Concerning corn particularly, the tight husk offers much protection, and in the field the angoumois grain moth or rice weevil would be excluded almost completely from ears with a husk fitting tightly over the end, were it not for the corn ear-worm, which frequently makes entrance and exit holes, that furnish easy entrance for the grain moths or beetles. However, the presence of the ear-worm is an argument in favor of housing the grain as early as practicable. The longer it is left in the field the greater will be the number of ears infested. Of course, if the farmer does not see that the barns and granaries are free from insects when the grain is stored, the extent of the field infestation is of less importance.

Cleanliness.—The ideal place to store grain is in a special building separated from the barns, but when grain must be stored in the latter place all old infested grain should be used before the new crop is housed, and precautions should be taken to guard against leaving heaps of waste corn, or other material in which the grain insects may be feeding. The writer has known many farmers to place new corn on top of a few bushels of old corn literally being devoured by the weevils and other insects. Farmers will also often boast that their bins or cribs are never emptied. This practice cannot be too strongly condemned.

Storing Corn in the Husk.—It has often been observed that unhusked corn is less liable to weevil injury, and this is true with varieties that have a tight-fitting husk, when not too badly injured by the ear-worm. In Fig. 16 is shown an ear of corn two years old which was taken from the same lot as the one shown in Fig. 3. It is seen from this cut how the tightly fitting husk acted as a protection. In the same lot, however, the ears on which the husk was loose were all badly injured. When it is considered that corn is nearly always first infested in the field, the value of storing unhusked corn seems somewhat doubtful.

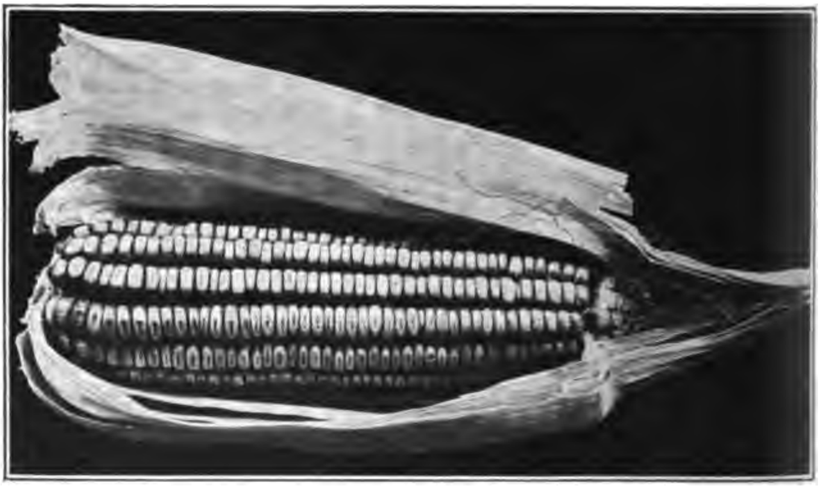


FIG. 16.—Two-year-old Corn showing protection from weevils afforded by a tight-fitting husk—about one-half natural size.

Moth Traps.—All the grain moths are nocturnal in habits and may be attracted to lights. By placing in the corn cribs wide shallow pans containing a little kerosene, with a lantern suspended just above or set in the middle, hundreds of moths may be trapped. They will fly to the light and fall into the pan, and even if they escape again the kerosene will kill them. These traps may be used in the spring when the angoumois grain moth commences to emerge, or at any other time when they are abundant.

Repellents.—Various substances have been tried for sprinkling over grain in storage to repel the parent insects, but few are of practical value. Salt, air-slaked lime or powdered sulphur are said to be employed with some success. Naphthalene flakes act as a powerful repellent, but its use is objectionable, and the same is more or less true of the other substances named.

FUMIGATION TREATMENT.

The destruction of insects in stored grains or cereal products, by poisonous fumes, has been recommended by so many writers that many people have come to the conclusion that the treatment must be perfectly reliable; but experience would teach otherwise. Carbon bisulphide is the chief dependence, but other substances, such as benzine, naphtha, carbon tetrachloride, burning sulphur fumes and hydrocyanic acid gas, have been suggested. The last named is a deadly poison, and if used for fumigating in a perfectly air-tight space would be certain death to all grain insects. It is too dangerous, however, to be recommended for general use.

Sulphur Fumes.—The fumes of burning sulphur, chemically known as sulphur dioxide, have long been known as a powerful fumigant and disinfectant, and have been used successfully for destroying rats and other animals. For several years it has been recognized that sulphur fumes would kill insects. During the past fifteen months the writer has made many experiments to see if this knowledge could not be made use of in killing grain pests. The results proved conclusively that sulphur fumes will kill grain insects, not only the adult forms, but the larvæ and pupæ of the rice weevil and angoumois grain moth as well; but the germinating power of the grain so treated is destroyed or much weakened. It was found that the fumes produced by burning two and one-half pounds of sulphur either in a moist or dry atmosphere of one thousand cubic feet space, for twenty hours, would kill all exposed adult insects and practically all the young stages in the grain, but that this also destroyed its germinating power. In making these experiments the sulphur was placed in a metal dish, one side of the pile wet with alcohol, which was sufficient to start the sulphur burning by simply applying a match.

While this treatment cannot be recommended for general fumigation, there is no doubt of its being the easiest and cheapest method of fumigating corn cribs, granaries and similar places whenever they are being cleaned out and freed of insects in preparation for the reception of more grain. The amount stated above will kill all insects if the space is made practically air-tight, but if the fumes escape through cracks the amount necessary for successful fumigation cannot be estimated, and the same statement would be true of any poisonous gas.

Carbon Bisulphide Treatment.—Carbon bisulphide is a heavy, clear, foul-smelling liquid, which evaporates rapidly when exposed in shallow dishes. The vapor is a deadly poison when confined in sufficient quantity, and has been extensively used for killing all kinds of insects in stored grain, cereal products, or other material. The amount required is claimed by excellent authorities to be only one pound in 1,000 cubic feet of space, provided there is no escape of the poisonous vapor for about twenty-four hours. This means ideal fumigating conditions, which cannot be secured under ordinary circumstances. The question therefore becomes, what amount of carbon bisulphide must be used to overcome the loss due to leakage? The writer has recently conducted numerous experiments, all of them showing that the diffusibility of carbon bisulphide fumes is greater than generally supposed, and that fumigation of corn, for instance, in a well made, apparently tight grain bin, may not result in killing weevils unless twenty or more times the usually recommended amount be used.

The vapor of carbon bisulphide is 2.64 times heavier than air, so that it settles rapidly if exposed on the top of grain or whatever is being fumigated. This fact has led many people to suppose that it can be used successfully in any space with air-tight sides and bottom, provided the top is covered to exclude currents of air, and that under these conditions the heavy vapor would not escape. It does, however, diffuse in the same manner as other gases, although not as rapidly as those of less specific gravity, and recent experiments have shown that if there is any chance of leakage from the top, the expected results will not be obtained. Where will we find a farmer's grain box, corn crib, or storeroom that can be made air-tight without prohibitive trouble and expense? Not in North Carolina or any other farming district!

One writer has made the statement that, "one pound of carbon bisulphide poured over one hundred bushels of corn will kill all the insects even in open cribs," and farmers are constantly being advised to fumigate with two or three pounds to one thousand cubic feet of space, in fairly tight rooms.

RESULTS OF EXPERIMENTS.

The adult grain moths are killed by the vapor from a small quantity of carbon bisulphide, but the grain beetles require a much greater strength, and it is even more difficult to kill the young stages, larva and pupa, of the rice weevil and angoumois grain moth, in their burrows. The writer has made numerous experiments with grain insects in all stages, using a practically air-tight fumigating room, one having a padded refrigerator style door and the inside walls covered with asbestos. In this it was found that three pounds of carbon bisulphide to one thousand cubic feet, fumigating for twenty-one hours, killed practically all adult insects, but not over seventy per cent of the larvæ and pupæ of the angoumois grain moth or rice weevil.

For an experiment corresponding to farm conditions a grain box of about forty cubic feet capacity was used; the sides were made of matched boards and the floor of concrete; the top edges were covered with sacks and the hinged cover nailed down on three sides when fumigation commenced. The bin was about one-third full of bran. Carbon bisulphide was used by exposing it in shallow dishes near the cover, tests being made with ten, fifteen and twenty pounds, respectively, to one thousand cubic feet space, for twenty-four to twenty-six hours. Larvæ, pupæ and adults of both rice weevil and angoumois grain moth and adult cadelle beetles were used in each test. It was found that the greatest strength used did not kill all the insects twelve inches below the cover, and the average result was not equal to that obtained by using three pounds for twenty-one hours in the tight fumigating room, already described. In view of these results, the writer is forced to conclude that carbon bisulphide, at any reasonable strength, cannot be successfully used for fumigating grain in ordinary corn cribs, grain boxes or storerooms.

Small quantities of infested grain can be fumigated in absolutely tight boxes or barrels by using about one ounce to three bushels. The top must be rendered air-tight, not simply covered with blankets or canvas. Fumigation should continue for about twenty-four hours.

Caution.—The vapor of carbon bisulphide is inflammable and explosive, hence those who use it must be certain that no lighted lanterns or fire of any kind be brought around where fumigation is being made. Any supply on hand should be kept securely sealed and placed in a ventilated room. As a further precaution it may be marked "Inflammable."

The purchase price is about thirty to thirty-five cents a pound from retail druggists, but as low as eight or ten cents per pound when ordered from the manufacturers, who make a commercial grade especially for fumigating purposes.

BULLETIN 204 JUNE, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

SOME FACTORS INVOLVED IN SUCCESSFUL CORN GROWING.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.

Governor W. W. Kitchin, *ex officio* Chairman, Raleigh.

C. W. Gold	Raleigh
E. M. Koonce	Jacksonville
T. W. Blount	Roper
D. A. Tompkins	Charlotte
J. T. Ellington	Smithfield
W. E. Daniel	Weldon
W. H. Ragan	High Point
W. B. Cooper	Wilmington
M. B. Stickley	Concord
T. T. Ballenger	Tryon
N. B. Broughton	Raleigh
O. L. Clark	Clarkton
Everett Thompson	Elizabeth City
R. H. Ricks	Rocky Mount
O. Max Gardner	Shelby
Locke Craig	Asheville

STATION STAFF.

D. H. Hill, President of the College.

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
G. A. Roberts	Veterinarian
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant in Farm Crops
J. K. Plummer	Assistant Chemist
A. R. Russell	Assistant in Field Experiments
P. L. Gainey	Assistant Bacteriologist
F. W. Sherwood	Assistant Chemist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

TABLE OF CONTENTS.

PAGE.

Introduction 5
Starting Work 5
Testing Varieties 6
What is a Variety? 7
Early Maturing Varieties 8
Medium Maturing Varieties 9
Late Maturing Varieties 9
Varieties Adapted to Eastern or Coastal Section 10
Varieties Adapted to Piedmont Section 10
Varieties Adapted to Mountain Section 11
Northern Versus Southern Varieties 12
Factors Affecting Period of Maturity 14
    Effect of Variety 14
    Effect of Soil 16
    Effect of Season 18
    Effect of Elevation 18
    Effect of Latitude 18
    Effect of Fertilization 20
    Effect of Date of Planting 21
Some Largely Controllable Factors Affecting Yield 22
    Earliness in Maturity 22
    Seed Selection 22
Methods of Improvement 23
    Importation of Seed 23
        Buying Seed 25
        Acclimatization of Corn 26
Field Selection of Seed 28
    Uniformity in Height of Ears 28
    Barn Selection 29
    Result of Proper Seed Selection 30
Field Selection and Growth of Seed in an Isolated Field 30
Characteristics to Consider in Seed Selection 32
    Percentage of Grain 32
    Height of Ears and Stalks 32
    Number of Ears per Stalk 32
    Which of Two Ears to Select 34
    Large Versus Small Ears 34
    Stalks 36
    Ears 36
        Position on Stalk 36
        Shank 38
        Shape 38
        Color 38
        Size of Cob 38

Characteristics to Consider in Seed Selection— PAGE.
  Ears, Length and Circumference.......... 38
    Filling of Butts and Tips.......... 38
    Number of and Distance Between Rows of Kernels.......... 38
  Kernels 38
Vitality of Seed.......... 40
Nubbing Ears 40
White Versus Yellow-Eared Varieties.......... 40
Relation of Characters.......... 41
  Antagonistic Characters 41
  Associated Characters 42

SOME FACTORS INVOLVED IN SUCCESSFUL CORN GROWING.

By C. B. Williams, Director.

Information concerning proper methods of selecting seed of different farm crops is of vital importance to farmers, for the same thought and effort put into few other operations of the farm bring such good financial returns. A few hours spent in intelligent field selection of seed of corn each year may be expected to lead to an annual increase of two to five bushels more per acre from these seed than from those selected by the ordinary methods.

In consideration of the promise in this neglected field of work in North Carolina, and that over forty-seven per cent of all land cultivated in the State is devoted to corn, with the use of something like 450,000 bushels of seed corn and a small average annual yield of 13.4 bushels of shelled corn per acre, the Experiment Station six years ago began experiments to determine the relative value of different varieties of corn as producers of shelled corn per acre. During the time covered by these trials many cases in which one or more varieties have produced from five to ten bushels more per acre than other varieties have been observed. Conjointly with these experiments, seed selection work has been carried on with the hope of ascertaining much practical information, the application of which by farmers would lead to materially increased yields of this cereal.

It should be borne in mind, in the beginning, that the underlying principles of plant and animal improvement are almost identical, and that similar methods to those which have been adopted in the improvement of the various breeds of live stock must be followed by those who wish to grow plants of increasing productiveness. It must also be remembered that as intelligent feeding and good care stand to animal breeding, so do proper fertilization and thorough cultivation of the soil stand to plant breeding or improvement; for if proper food and care are not furnished both plants and animals, improved breeding will not only be impossible, but retrogression inevitable. With the same thought and care, results are secured much quicker with plants than with animals, as a completed growth is obtained in one year with most plants, while with animals it requires several years to secure complete knowledge of what one has obtained by a certain cross.

STARTING WORK.

The method that is being followed by the Station is to conduct comparative tests of all the known varieties of promise grown and offered for sale in this and nearby States through a sufficient number of years to secure average weather conditions.

With the variety or varieties demonstrated by these tests to be the most prolific of shelled corn per acre, field seed selection for further improvement was begun and systematically continued; having uppermost in mind, in selecting seed, total yield per acre. By this means it has been observed that the yielding power of a variety may be greatly increased within a few years.

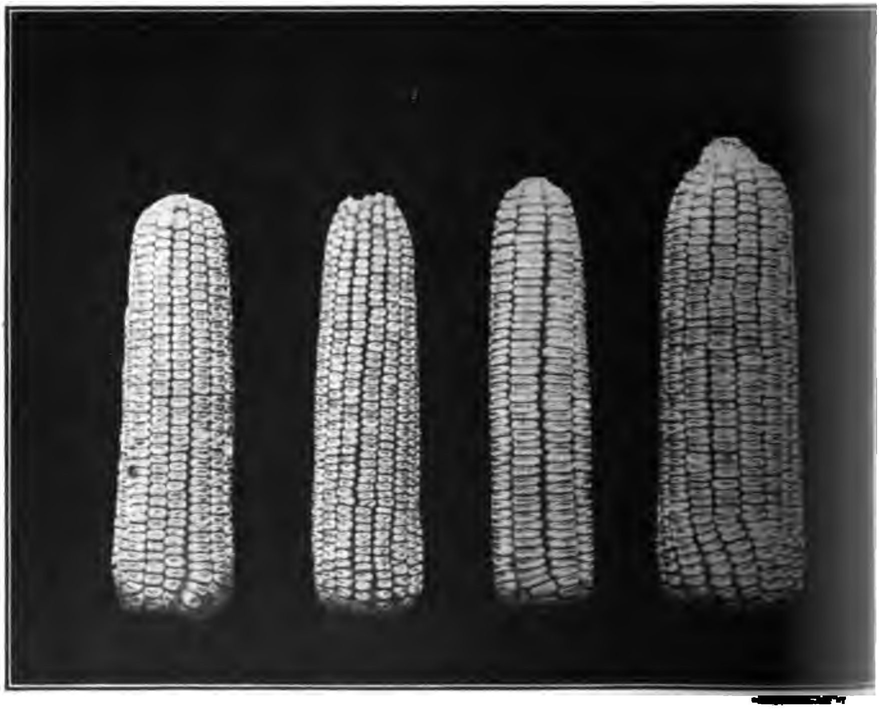


FIG. 1.—Type Ears of Varieties: (1) Sharber's; (2) Jackson's Whitecap Prolific; (3) Hickory King (Virginia); and (4) McAuley's White Dent.

TESTING VARIETIES.

The testing of varieties of all agricultural crops is of the most fundamental importance, as is evidenced by the differences in yield of different varieties grown side by side in the same field, on the same type of soil, with identical cultivation and fertilization; these differences being du largely to the inherent qualities of the seed of the individual varietie which have been transmitted from parent to progeny.

During the past six years on the Station farm something over sevent five varieties of corn have been studied in comparative field tests. Th number of varieties in the different tests have ranged all the way fro nineteen in 1903 to sixty-eight in 1908. The different tests of varietie were conducted as nearly under the same conditions of soil, fertilizatio and cultivation as it was possible to provide. To eliminate inequalities in the character of the land, if any, the varieties were planted each in separate rows, arranged consecutively, and this plan was repeated from three to five times, varying with the length of the rows, in order to give the desired acreage to each variety. By taking these precautions the results obtained should be reliable and highly valuable.

WHAT IS A VARIETY?

A variety is supposed to represent a class of plants with one or more distinguishing characteristics, but with a cereal like corn, which mixes so freely that variety does not mean much unless proper precautions have been exercised in its growth.

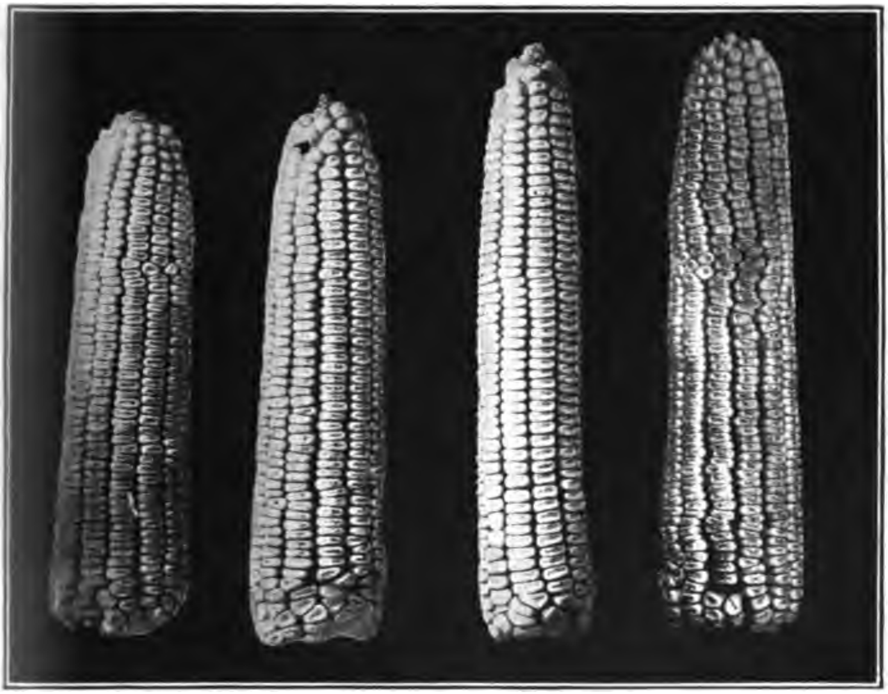

(5) (6) (7) (8)

FIG. 2.—Type Ears of Varieties: (5) Cocke's Prolific; (6) Weekley's Improved; (7) Shellem's Prolific; and (8) Wilson's Success.

Take some variety of corn—say Cocke's Prolific—that has been bred carefully and intelligently for about an hundred years for high yield of shelled corn per stalk, and grow it continuously in or adjacent to a field of inferior corn, and in a very short time, especially if proper seed selection is not practiced, it will give much smaller yields when grown under the same conditions than the original pure-bred corn; this being due to the fact that you no longer have pure Cocke's Prolific, but a mixture of scrub and Cocke's Prolific corn. This fact emphasizes the importance of securing seed from reliable parties.

EARLY MATURING VARIETIES.

Leaming Yellow, Iowa Silvermine, Riley's Favorite, Reid's Yellow Dent, Boone County White, Boone County Special and Pool's are seven of the earliest varieties in maturing that have thus far been studied at the Station farm. These, with the exception of Pool's, which is from the upper Piedmont section of this State, were all originated and brought for the tests from the Western Central States, where they have been accustomed to a comparatively short growing season, which accounts largely for their inherent tendency to early maturity when grown under North Carolina conditions. Earliness, however, is not considered an important requisite with corn for this climate, except, possibly, where it is grown in the mountainous section of the State, or where corn, of necessity, has to be planted late, after the maturity of some truck crop, like Irish potatoes. Under these circumstances it may be well to use one of the varieties mentioned above, especially if experience has taught

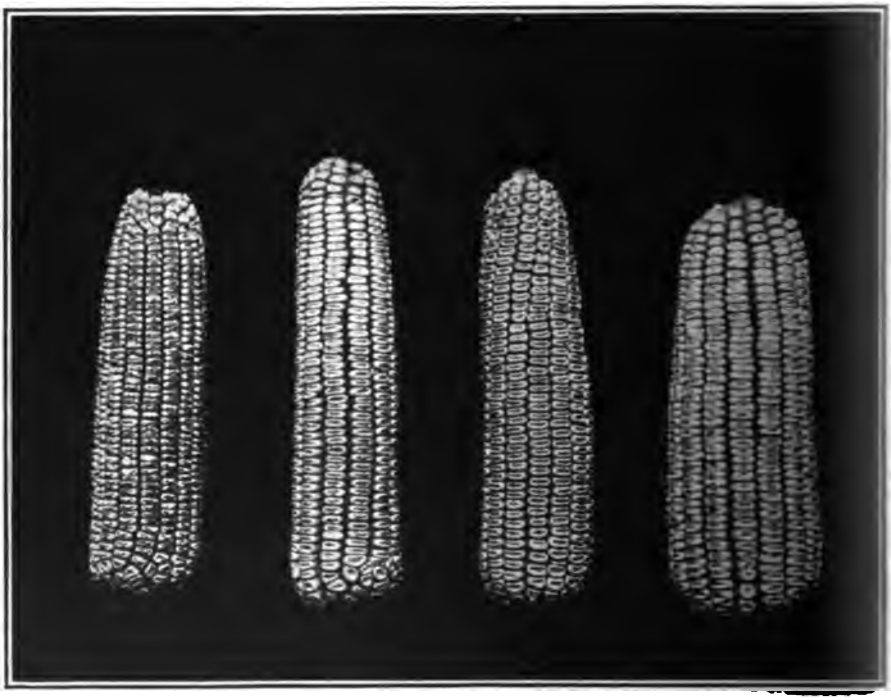
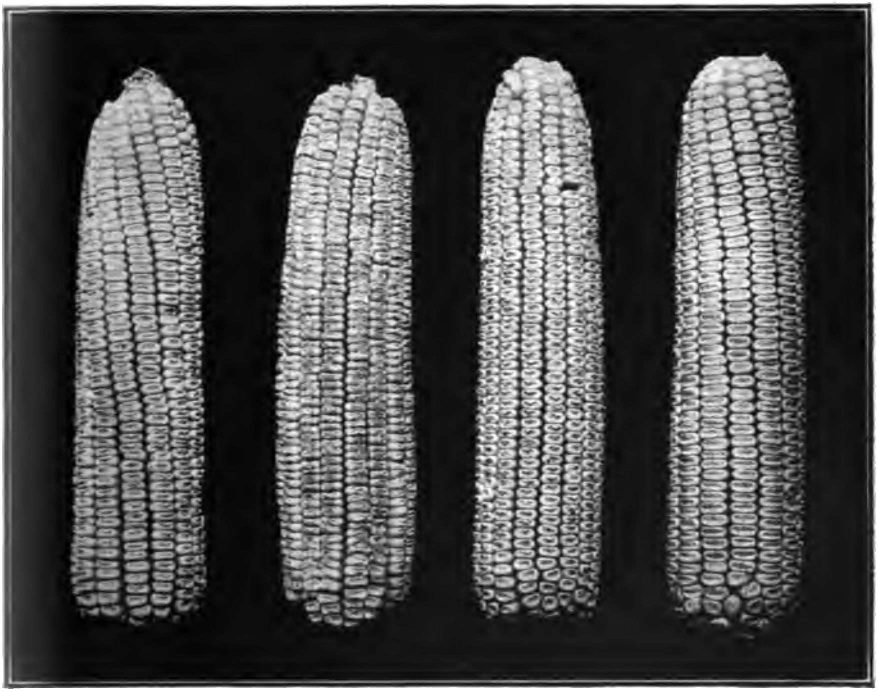

(9) (10) (11) (12)

Fig. 3.—Type Ears of Varieties: (9) Dodson's Prolific Shoepeg; (10) Culpepper's Extra Prolific; (11) Biggs' Seven-ear; and (12) Brake's.

the farmer that local varieties do not thoroughly mature before frost. Under North Carolina conditions of climate and soil these varieties will usually mature from planting in one hundred to one hundred and ten days.

MEDIUM MATURING VARIETIES.

Hickory King, Biggs' Seven-ear, Cocke's Prolific, Wyatt's Improved Yellow, MacMackin's Gourdseed, Peele's Prolific and Farmers' Favorite mature at a medium date in the fall, and some of these are the best yielders grown in the State. All these will usually mature on the different types of soil of North Carolina east of the mountains in one hundred and ten to one hundred and twenty days.



(13) (14) (15) (16)

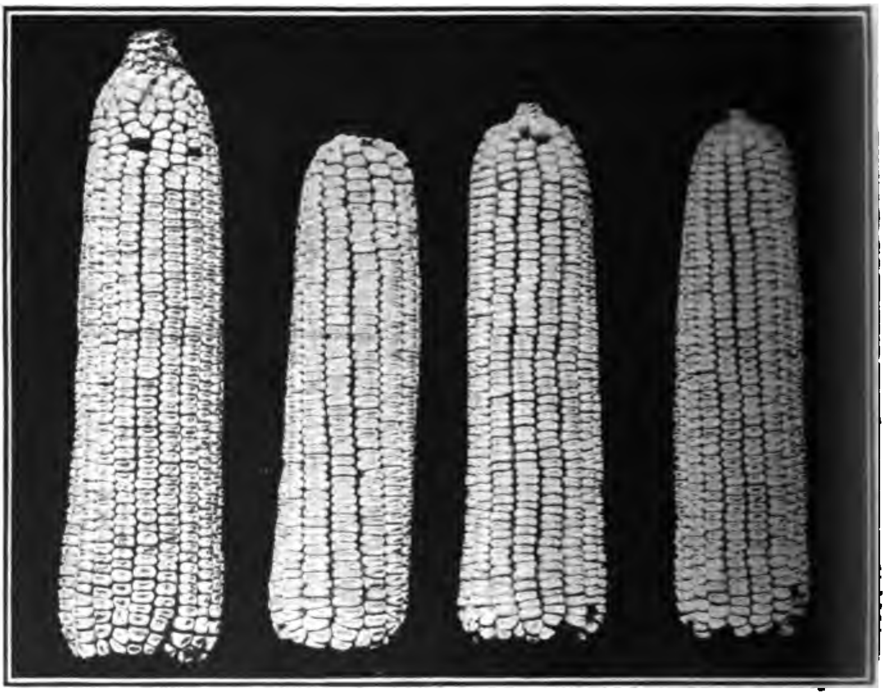
FIG. 4.—Type Ears of Varieties: (13) Williams'; (14) Krimminger's Improved; (15) Osborne; and (16) Farmers' Favorite.

LATE MATURING VARIETIES.

It has been found that Gourdseed, Hastings' Prolific, Mosby's Prolific, Brake's, Harris' Improved, Williams', Osborne, Horsetooth, Holt's Strawberry, Sanders' Improved, Fredonia's Pride, Latham's Improved, Weekley's Improved, Marlboro Prolific, Henry Grady, Bagley's Improved, Cleckler's Improved, Cooper's Improved, Jarvis' Improved, Fry's Improved and Sharber's, in about the order named, are some of the latest maturing varieties tested during the past four or five years. These varieties are vigorous growers and generally produce large, tall stalks, and many of them have evidently been bred to produce one large ear per stalk. In this climate they will mature usually in one hundred and twenty to one hundred and thirty-five days.

VARIETIES ADAPTED TO EASTERN OR COASTAL SECTION.

For the sandy and fine sandy loam soils of the eastern and southeastern portions of the State, Cocke's Prolific, Biggs' Seven-ear, Weekley's Improved, Sanders' Improved, Hickory King, Holt's Strawberry, American Queen, Bagley's Improved, Brake's, Cooper's Improved, Jarvis' Improved and Latham's Improved are recommended as good varieties for planting, if pure seed are secured. Of these varieties Biggs' Seven-ear, Weekley's Improved, Cocke's Prolific and Sanders' Improved, in the order named, are the most prolific. Bagley's Improved, Jarvis' Improved and Brake's possess the largest ears.



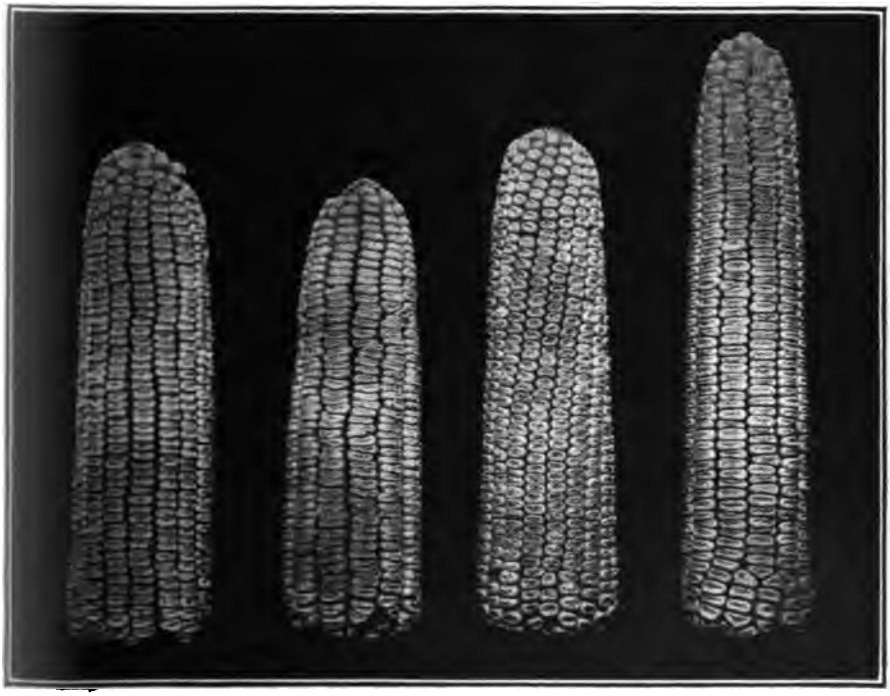
(17) (18) (19) (20)

—FIG. 5.—Type Ears of Varieties: (17) Harris' Improved; (18) Whelchel's Dent; (19) Cooper's Improved; and (20) Peele's Prolific.

VARIETIES ADAPTED TO PIEDMONT SECTION.

It has been found from a testing of a large number of varieties during the past six years that Biggs' Seven-ear, Sanders' Improved, Weekley's

Improved, Cocke's Prolific, Marlboro Prolific, American Queen, Brake's, Holt's Strawberry, Southern Beauty, Bagley's Improved, Farmers' Favorite, Boone County White, Hickory King and Horsetooth are the largest yielders of shelled corn per acre of all the varieties thus far tested for elevations below about 2,500 feet. These are all white-eared varieties, with the exception of Holt's Strawberry, and are medium to medium late in maturity. It will be observed that many of these are the leading varieties recommended for the eastern portion of the State, but the order as yielders of the varieties is somewhat changed.



(21) (22) (23) (24)

Fig. 6.—Type Ears of Varieties: (21) Goodman's Prolific; (22) Columbian Beauty; (23) Jones' White; and (24) Wright's Improved.

VARIETIES ADAPTED TO MOUNTAIN SECTION.

For those portions of the transmontane region elevated more than 2,500 feet above sea level, and which are devoted to the growth of corn, Boone County White, Leaming Yellow, MacMackin's Gourdseed, Riley's Favorite, Iowa Silvermine and Reid's Yellow Dent are suggested as varieties of dent corn which may be grown to good advantage. For those mountain plateaus elevated about 2,800 to 3,000 feet and which have quite cool nights it will be found that the flint types of corn will do well.

NORTHERN VERSUS SOUTHERN VARIETIES.

As pointed out elsewhere in this Bulletin, the best of the northern-grown varieties of corn have not proven to be the heaviest yielders for the cismontane portions of North Carolina. Neither have varieties coming from the far South yielded as well as the best of those seed which have come from nearer home. In the Station tests, Biggs' Seven-ear, a North Carolina originated variety, has as an average of three years' results, produced 2.4 bushels more of shelled corn per acre than has Reid's Yellow Dent, originated in Illinois, and 4.2 bushels more than Mosby's Prolific, bred in southern Mississippi. Southern corn generally produces a larger and taller stalk, and bears the ears at a greater height, than do those varieties brought from higher elevations and latitudes. The northern varieties, on the other hand, produce a larger ear in proportion to the size of the stalk than do Southern varieties, as is shown by the results contained in Table I. It will also be noted from these data that the percentage the ear is of total plant of both Southern and Northern varieties increases, with only four exceptions, as the yields are made better. The average percentage of ear of total dry plant, as an average of four years' tests, is, for the five Southern varieties, 40.9 per

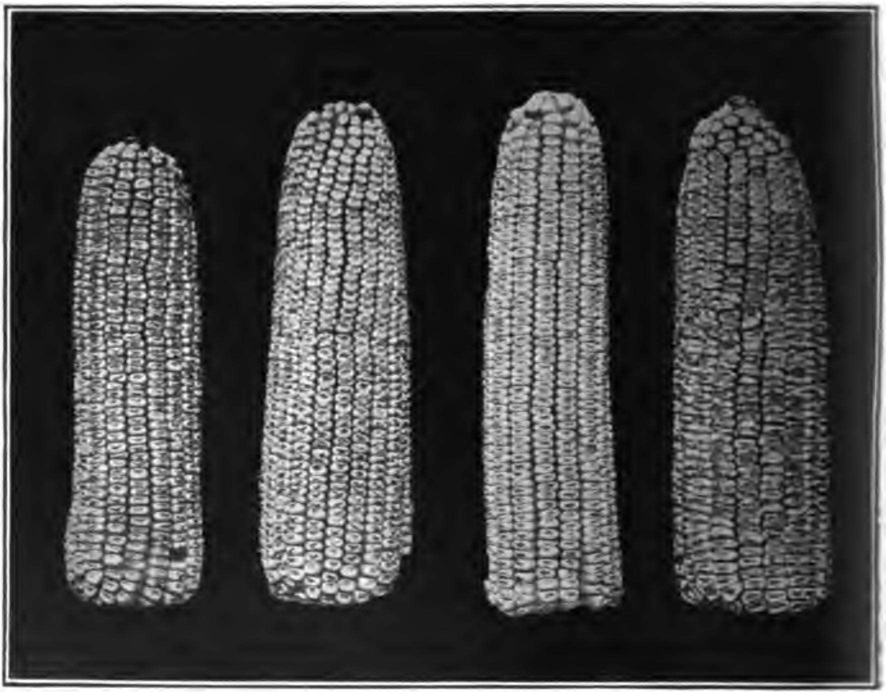


Fig. 7.—Type Ears of Varieties: (25) Cleveland's Pure White; (26) Fredonia's Pride; (27) Thomas' Improved; and (28) Horsetooth.

TABLE I.—SHOWING FIVE YEARS' YIELD OF GRAIN AND EAR PERCENTAGE OF TOTAL PLANT OF SOUTHERN AND NORTHWESTERN VARIETIES OF CORN WHEN ALL WERE GROWN UNDER THE SAME CONDITIONS.

VARIETIES.	SOURCE OF SEED.	1903.		1904.		1905.		1906.		1907.		Average of Four Years.	
		Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Acre.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.	Ears of Total Plant—Per Cent.	Yield of Grain per Acre—Bushels.[1]	Ears of Total Plant—Per Cent.
Southern Varieties.													
Cocke's Prolific	North Carolina	20.2	41.1	24.8	42.9	31.9	56.4	24.4	------	15.9	30.0	23.2	42.6
Weekley's Improved	North Carolina	19.8	44.0	22.1	40.8	28.1	48.4	20.8	------	23.7	36.6	23.4	42.5
Sanders' Improved	Georgia	23.2	42.2	25.1	43.2	31.7	49.0	21.2	------	20.2	33.8	25.1	42.1
Cocke's Prolific	Tennessee	20.1	39.4	20.6	43.4	25.9	43.3	22.3	-----	18.4	31.7	21.3	39.5
Mosby's Prolific	Mississippi	19.5	38.1	21.5	39.8	24.7	42.8	20.5	------	14.6	31.3	20.1	38.0
Averages		20.6	41.0	22.8	42.0	28.5	48.0	21.8	------	18.6	32.7	22.6	40.9
Northwestern Varieties.													
Iowa Silvermine	Illinois	15.7	36.9	20.7	48.6	26.9	58.3	21.4	------	17.6	45.3	20.2	47.3
Leaming Yellow	Ohio	19.4	46.6	23.7	55.0	29.6	63.6	20.5	------	19.4	48.9	23.0	53.5
Reid's Yellow Dent	Illinois	18.2	45.4	25.1	51.9	28.3	57.1	21.6	------	20.3	42.5	23.0	49.2
Riley's Favorite	Indiana	15.1	44.0	23.7	50.7	27.3	57.9	20.2	------	20.1	44.1	21.6	49.2
Boone County White	Indiana	14.4	37.9	21.8	47.4	29.2	54.4	22.7	------	21.0	44.8	21.6	46.1
Averages		16.6	42.2	23.0	50.7	28.3	58.3	21.3	------	19.7	45.1	21.9	49.1

[1] The data in this column do not embrace the results secured in 1906.

cent, and for the five Northern varieties, 49.1 per cent. With the average yield of the Northern corns, being 0.7 bushels less per acre, they have produced 8.2 per cent more ear to total plant than did the varieties from the South.

FACTORS AFFECTING PERIOD OF MATURITY.

With corn as with other plants, the number of days required for the growth of the plants from the sprouting of the seed to full maturity is governed, within narrow limits, by variety, soil, season, elevation, fertilization, date of planting and source of seed. Of the varieties grown in different portions of North Carolina, it usually requires from one hundred to one hundred and forty days to make a completed growth from planting.

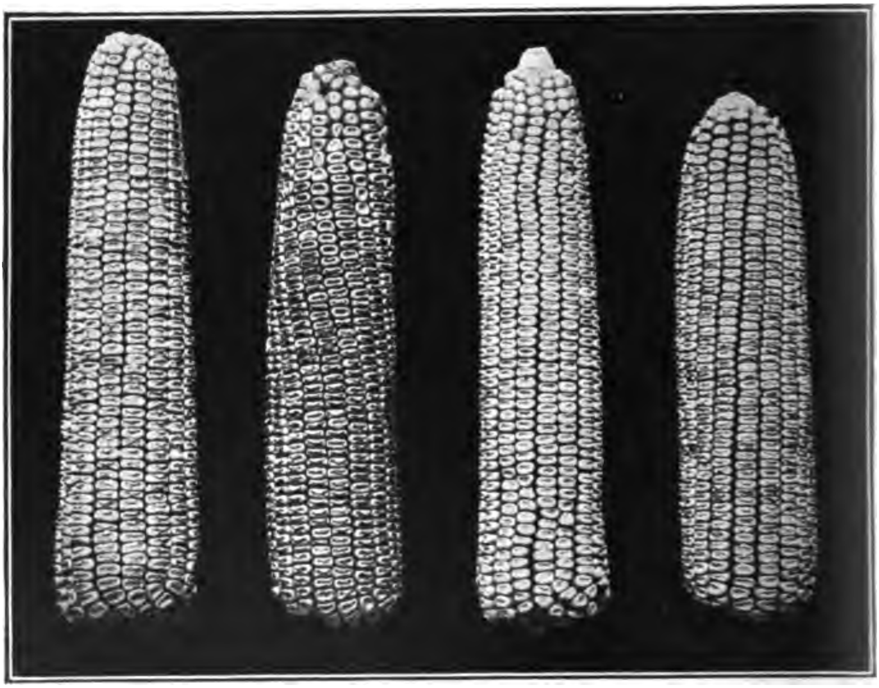


FIG. 8.—Type Ears of Varieties: (29) Leaming Yellow; (30) Kansas Sunflower; (31) Jones' Yellow Dent; and (32) Hildreth's Yellow Dent.

Effect of Variety.—In the study of varieties of corn during the past few years many instances of differences in earliness in maturity of varieties, originated under the same conditions and sometimes by the same grower, have come under the observation of the writer. To some extent the originator or improver of a variety may select seed in such a manner as to have the variety within a few years mature at either an early, medium or late date. Jarvis' Improved, which was originated

4

TABLE II.—NUMBER OF DAYS REQUIRED FROM PLANTING TO TASSELING AND MATURITY OF TWENTY-ONE VARIETIES OF CORN DURING SIX YEARS.[1]

VARIETIES.	SOURCE OF SEED.	1903.		1904.		1905.		1906.		1907.		1908.		Average of 1903–1908.		Average of 1906–1908.	
		Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.
Biggs' Seven-ear	North Carolina	------	------	78	122	------	------	72	121	74	116	58	116	------	------	68.0	117.7
Hickory King	Tennessee	71	123	------	------	58	110	65	120	67	115	50	114	------	------	60.7	116.0
Cocke's Prolific	North Carolina	71	126	73	122	63	110	70	120	71	115	56	117	67.3	118.3	65.7	117.3
Marlboro Prolific	South Carolina	71	124	------	------	63	110	72	120	76	121	57	114	------	------	68.3	118.3
Boone County White	Indiana	62	121	64	115	53	104	65	113	66	111	55	105	60.8	111.5	62.0	109.7
Boone County White	Tennessee	64	121	68	115	58	104	68	113	69	111	55	116	63.7	113.3	64.0	113.3
Cocke's Prolific	Tennessee	71	126	78	122	63	110	------	120	78	119	------	------	------	------	------	[4]119.5
Southern Beauty	North Carolina	------	------	------	------	------	------	71	121	69	115	56	117	------	------	65.3	117.7
Peele's Prolific	North Carolina	------	------	------	------	63	110	69	121	------	------	56	118	------	------	------	[5]119.5
MacMackin's Gourdseed	Tennessee	------	------	78	126	63	118	68	120	72	119	57	114	------	------	66.0	117.7
Reid's Yellow Dent	Illinois	62	117	66	115	53	101	64	106	66	111	57	114	61.3	110.7	62.3	110.3
Iowa Silvermine	Illinois	59	117	63	114	53	97	61	106	61	106	52	101	58.2	106.8	58.0	104.3
Sanders' Improved	Georgia	71	126	73	126	63	110	74	121	74	120	59	121	69.0	120.7	69.0	120.7
Selection 77	Ohio	59	121	64	115	53	110	65	113	65	111	54	105	60.0	112.5	61.3	109.7
Weekley's Improved	South Carolina[2]	69	124	73	122	63	110	72	123	75	121	57	119	68.2	119.8	68.0	121.0
Boone County Special	Indiana	------	------	64	114	53	104	68	113	67	111	56	105	------	------	63.7	109.7
Mosby's Prolific	Mississippi	75	126	78	126	70	118	------	126	79	127	56	120	------	------	------	124.3
Leaming Yellow	Ohio	59	117	60	114	53	97	57	106	59	102	48	98	56.0	105.7	54.7	102.0
Farmers' Favorite	North Carolina	------	------	------	------	------	------	68	116	74	120	53	106	------	------	65.0	114.0
Riley's Favorite	Illinois	59	117	61	114	53	101	59	106	62	106	51	105	57.5	108.2	57.3	105.7
Eureka	Virginia	------	------	------	------	63	110	78	121	------	------	56	116	------	------	------	[5]118.5
Averages[3]		63.5	120.7	66.5	117.2	56.5	104.4	65.5	112.7	66.8	111.4	54.4	110.1	------	------	63.5	113.2

---

[1] All the varieties were planted as follows: On May 4 in 1903; on April 30 in 1904; on May 19 in 1905; on May 8 in 1906; on May 14 in 1907; and on June 9 in 1908.

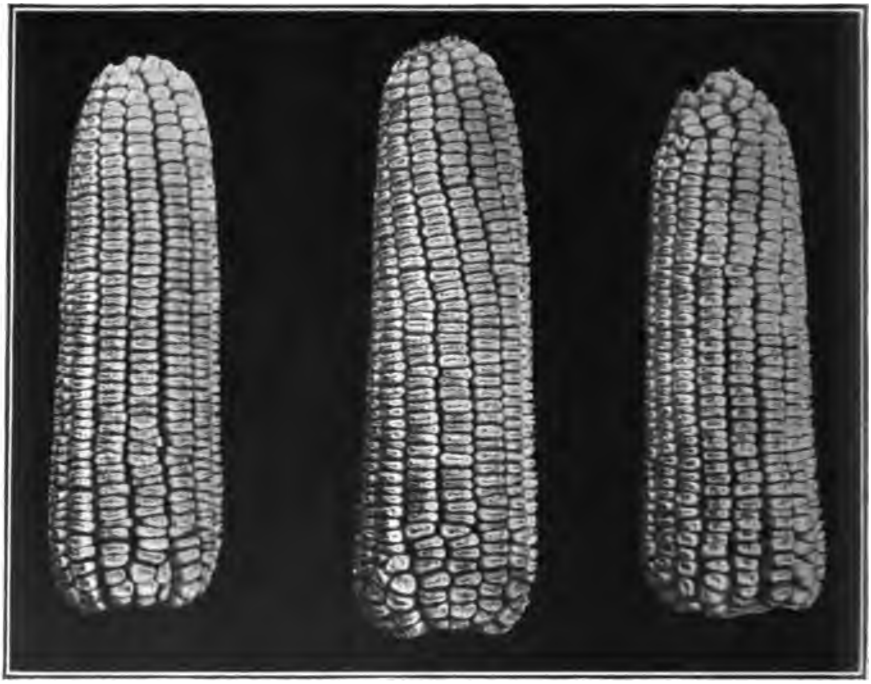
[2] Seed of Weekley's Improved for planting after 1904 came from the Iredell Test Farm, North Carolina.

[3] These averages, except in the last two columns, are made up only of the results secured from the ten varieties which were tested continuously for the six years under consideration.

[4] Average of results of 1906 and 1907 only.

[5] Average of results of 1906 and 1908 only.

in the same section as Sharber's corn, matured, during the past two years, on an average, at the Station farm, four and one-half days earlier than the latter, when both were grown under identical conditions of soil, fertilization and cultivation. In the variety tests during 1903, 1904, 1905, 1906, 1907 and 1908, as seen by Tables II and III, Boone County White averaged four days later in maturing than did Riley's Favorite, originated in Indiana by the same grower. In comparing varieties from different sections of the country and originated on different soils, as great differences as twenty days have been found in date of maturity, but other factors than variety enter here to make these differences.



(33) (34) (35)

FIG. 9.—Type Ears of Varieties: (33) Jarvis' Improved; (34) Henry Grady; and (35) Fry's Improved.

Effect of Soil.—Other things being equal, soils made up of sand, partially or totally, when well drained, warm up much earlier in the spring than do soils containing much clay, because of their low specific heat. Soils which are open in their nature and normally contain small percentages of water may be plowed and planted to crops much earlier in the spring than those of a more compact nature and which possess a much higher content of moisture. Generally, the darker the phase of the soil and the less moisture it contains, the earlier it will warm in spring and the quicker crops will start growth when put out on it. Crops grown on soils of a sandy or sandy loam character will usually

TABLE III.—COMPARISON OF SOUTHERN AND NORTHWESTERN VARIETIES OF CORN FOR FIVE YEARS WITH REFERENCE TO NUMBER OF DAYS REQUIRED FOR TASSELING AND MATURING.

VARIETIES.	SOURCE OF SEED.	1903.		1904.		1905.		1906.		1907.		Average of Five Years.	
		Date of Full Tasseling.	Date of Maturity.	Date of Full Tasseling.	Date of Maturity.	Date of Full Tasseling.	Date of Maturity.	Date of Full Tasseling.	Date of Maturity.	Date of Full Tasseling.	Date of Maturity.	Date of Full Tasseling.	Date of Maturity.
Southern Varieties.													
Cocke's Prolific	North Carolina	July 14	Sept. 7	July 11	Aug. 29	July 21	Sept. 6	July 12	Aug. 31	July 24	Sept. 6	July 16	Sept. 4
Weekley's Improved	North Carolina	July 12	Sept. 5	July 11	Aug. 29	July 21	Sept. 6	July 14	Sept. 3	July 28	Sept. 12	July 17	Sept. 5
Sanders' Improved	Georgia	July 14	Sept. 7	July 11	Sept. 2	July 21	Sept. 6	July 16	Sept. 1	July 27	Sept. 11	July 18	Sept. 5
Cocke's Prolific	Tennessee	July 14	Sept. 7	July 11	Aug. 29	July 21	Sept. 6	--------	Aug. 31	July 26	Sept. 10	[1]July 18	Sept. 5
Mosby's Prolific	Mississippi	July 19	Sept. 7	July 11	Sept. 2	July 28	Sept. 9	--------	Sept. 6	Aug. 1	Sept. 18	[1]July 23	Sept. 8
Averages		July 15	Sept. 7	July 11	Aug. 31	July 22	Sept. 7	--------	Sept. 2	July 27	Sept. 11	July 18	Sept. 5
Northwestern Varieties.													
Iowa Silvermine	Illinois	July 2	Aug. 29	July 1	Aug. 21	July 5	Aug. 24	July 3	Aug. 17	July 14	Aug. 28	July 5	Aug. 24
Leaming Yellow	Ohio	July 2	Aug. 29	June 28	Aug. 21	July 5	Aug. 24	June 29	Aug. 17	July 12	Aug. 24	July 3	Aug. 23
Reid's Yellow Dent	Illinois	July 5	Aug. 29	July 4	Aug. 22	July 5	Aug. 28	July 6	Aug. 17	July 19	Sept. 2	July 8	Aug. 26
Riley's Favorite	Indiana	July 2	Aug. 29	June 29	Aug. 21	July 5	Aug. 28	July 1	Aug. 17	July 15	Aug. 28	July 4	Aug. 25
Boone County White	Indiana	July 5	Sept. 2	July 2	Aug. 22	July 11	Aug. 31	July 7	Aug. 24	July 19	Sept. 2	July 9	Aug. 29
Averages		July 8	Aug. 30	July 1	Aug. 21	July 6	Aug. 27	July 8	Aug. 18	July 16	Aug. 29	July 6	Aug. 25

---

[1] Average of the results of 1903, 1904, 1905 and 1907.

mature several days earlier than when planted on clay soils. Ordinarily, crops planted on coarse sandy soils require a less number of days to mature than when grown upon clay soils.

Effect of Season.—With all soils, the drier the season the earlier, within narrow limits, the corn is forced to maturity. Cool weather towards the latter part of the growth of the plant, especially if accompanied by dryness, will tend to hasten maturity, while warm, seasonable weather during the early stages of maturity will prolong the date of ripening.

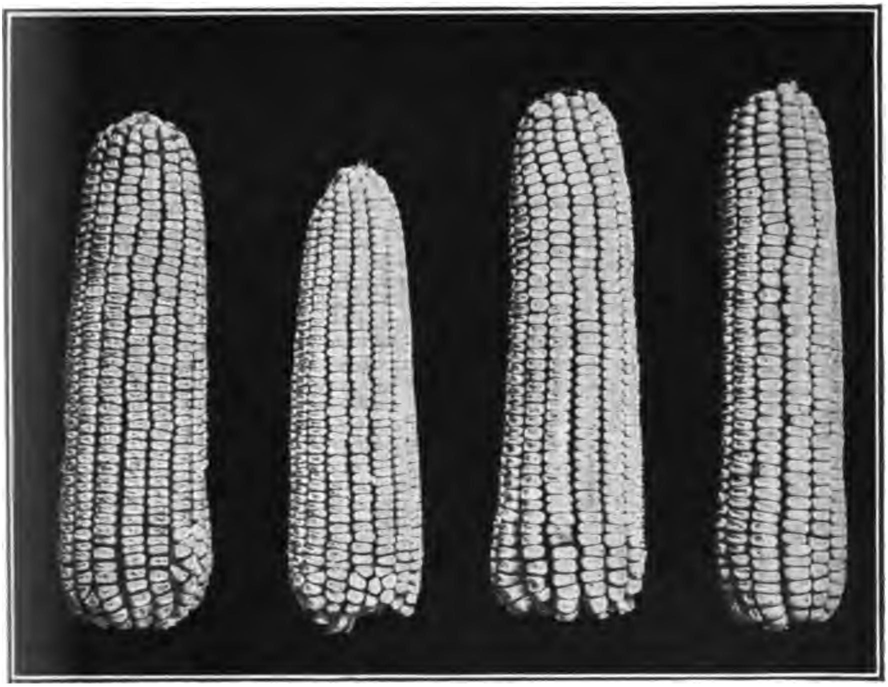
The seasonal effect upon maturity of corn is strikingly brought out by the average results of ten varieties given at the bottom of Table II. It will be observed from these data that the varieties required on an average to mature eight more days in 1903 and four and one-half days in 1904 than in 1906, and seven more days in 1907 than in 1905, when the date of planting did not differ more than five days between 1903, 1904 and 1906, and between 1905 and 1907.

During an ordinary season the moisture condition of the soil is a very potent factor in determining not only the amount and rapidity of growth, but also in influencing to a certain extent the length of time required by crops to complete their development.

Effect of Elevation.—In going from the seacoast to the mountains it is observed that the awakening season grows later, and generally the growing period of plants is gradually shortened as the elevation above sea level increases. The retardation of plant growth due to this cause is usually between one-half and one day per hundred feet of ascent; hence the opening season at Jefferson, North Carolina, will usually be between fourteen and twenty-eight days later than at Beaufort, North Carolina, as there is about 2,800 feet difference in the elevation of these two towns. Other factors than elevation, such as soil and rainfall, may enter in to make a difference in the beginning and length of period of growth of various crops in different localities.

Effect of Latitude.—In a general way it may be assumed, other conditions remaining the same, that going north or south of a given locality one degree (approximately 70 miles) will make a difference in the opening of the season of three to four days, while going east or west of a given locality, without change of rainfall, soil type or elevation, will produce but little difference. Going south, it will be found that the season is earlier, while going north there will be noticed a delay in the awakening of all vegetation.

From what has been said above, it will be seen that increasing the latitude (going north) by one degree, other conditions being equal, retards the opening of the season by approximately the same length of time as an increase in elevation of 300 to 400 feet. This is largely the reason why the section around Jefferson, North Carolina, and other localities of a like altitude have a similar climate and grow about the same kind of crops as are produced in central New York, which is about seven degrees farther north. It will be noticed, in going from Beaufort to Jefferson, this State, a distance of about 300 miles, due largely to a difference in elevation, that about the same retardation in the starting of plant growth in the spring is observed as would be in going from Beaufort to central New York, a distance of something like 550 miles. In going south it is usually found that the season is generally earlier by three to four days for each degree of decrease in latitude or reduction of 300 to 400 feet in elevation. For reasons given above, it has been observed that seed brought from Northern States or from the higher mountain regions, when sown in central or eastern North Carolina, grow more rapidly and the plants from them mature at an earlier date than do those from seed which are native to the warmer and lower portions of the State and of the South. It has been found, as shown in Table I, as an average of the results of five years' field experiments with five leading Southern and an equal number of Northwestern varieties of corn, that the seed from Illinois, Indiana and Ohio developed more rapidly than did the Southern-grown varieties. The average date of tasseling and maturity of those, seed of which came from the Northwest, were twelve days for tasseling and eleven days for maturity earlier than for the Southern varieties, when all were planted at the same date, on the same type of soil, at the Station farm, and received identical fertilization and cultivation. Varieties from the Northwest seem not only to be more precocious, but to suffer most from the effects of dry weather, as is shown



(36) (37) (38) (39)

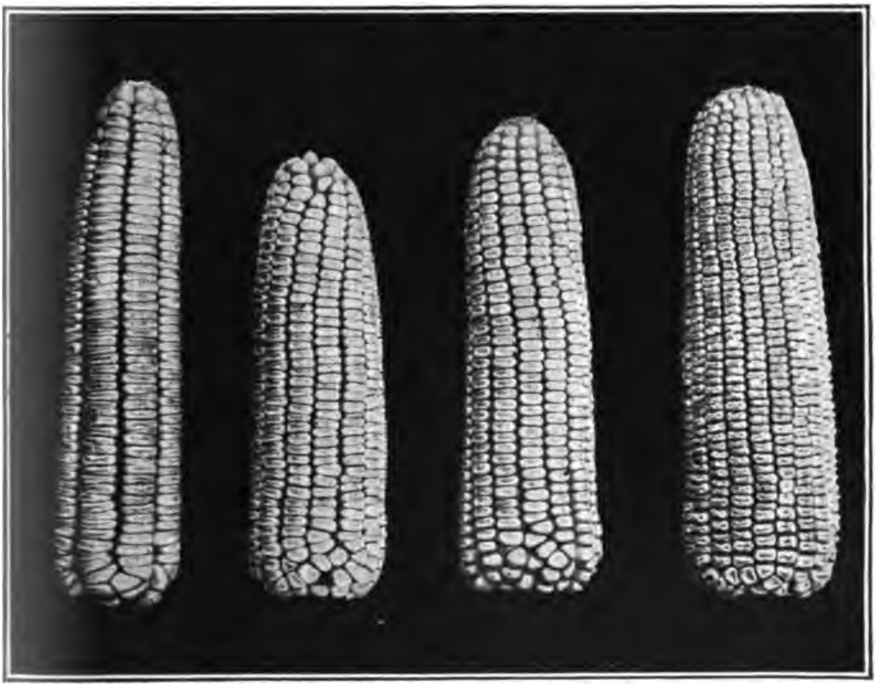
FIG. 10.—Type Ears of Varieties: (36) Wyatt's Improved Yellow; (37) Hastings' Prolific; (38) Marlboro Prolific; and (39) Cocke's Prolific (Tennessee).

in Table I, by their average for 1903, being four bushels less than the average of the yield of the five Southern corns. At the Station farm during the first part of August of this year the drought did considerable damage to all crops, but seems to have affected most severely those varieties brought from higher latitudes, as the differences of the averages of yields of the years 1904, 1905, 1906 and 1907 did not exceed one-half bushel for the varieties taken together from the two different sections. The entire crop during the season of 1907 was greatly reduced in yield as the result of drought, but was much more favorable to the earlier-maturing varieties, as a good rain fell just before the tasseling of these Northwestern varieties. It was quite dry before, during and after the tasseling stage of the Southern varieties. It has been found in studying varieties that usually those maturing latest are the ones seed of which have been brought into North Carolina from States located to the south of us. Those varieties originated farther south than 34 degrees north latitude have not been found generally to be among the best yielders for the State. Many of them, especially those from the more remote Southern localities and those of the one-ear type, have shown up poorly in the Station tests. Most of the late-maturing varieties originated within North Carolina have come from the eastern half of the State.

It might be stated in this connection that when varieties of corn from the Northern and Northwestern States are brought to the eastern or Piedmont sections of North Carolina and grown for a number of years the period required for their development is gradually lengthened as they become more and more acclimatized. As an illustration of this fact it has been found that Boone County White corn acclimatized to Tennessee has required 3.6 days more to complete its growth at the Station farm, as an average of three years' tests, than seed of the same variety secured from the originator in Indiana. With varieties brought from the extreme South the reverse takes place, as the time necessary to complete their growth is gradually shortened during the period of acclimatization. Varieties taken from the Coastal Plain to the mountains behave about the same as varieties brought from the South into the State, while those taken from higher altitudes and carried towards the coast conduct themselves quite similar to those seed of which have come from higher latitudes.

Effect of Fertilization.—Fertilization of corn and other crops, either with ordinary applications of commercial fertilizer or barnyard manure, has been found to hasten the maturity of the plants on poor upland soils. In the variety test last year, embracing a study of sixty-eight varieties, it was found that the corn in the sets receiving a liberal application of cow manure and fertilizer tasseled three days earlier than did the same varieties in other sets which received 300 pounds per acre of a fertilizer mixture analyzing 7 per cent available phosphoric acid, 3 per cent nitrogen and 1.5 per cent potash. With all these varieties there were but two (Brake's and Hickory King) which were exceptions to the general average and matured later on the highly manured plats. Even in the case of these the differences were quite small. It has also been observed that, as the whole plant development is accelerated, the period between tasseling and maturity is shortened. Also, in the regular fertilizer plats it has been observed for some years that the corn on those plats which were unfertilized tasseled and matured at a somewhat later date than did the corn on plats in the same series receiving an application of commercial fertilizer and worked in the same way.

Effect of Date of Planting.—Late-planted corn will usually reach the tasseling stage in a much shorter time than that which was planted early. From a study of the averages given at the bottom of Table II it will be seen that the ten varieties, results from which averages were taken, when planted during 1903, 1904 and 1906, at about the same date—the average of the three years being May 2—they required for these years an average of 10.8 days longer to arrive at the tasseling stage than it did for them in 1908, when the planting was delayed until June 9. During 1905 and 1907, with plantings made on May 19 and 14, respectively, the varieties prolonged their growth between planting and tasseling 7.3 days beyond that required for the same development in 1908. The number of days required to mature seems to be slightly decreased by late planting. In 1905, as shown by the results in Table II, the length of the period required to bring all the varieties to maturity was shorter than in any of the other years used in the study. This seems to



(40) (41) (42) (43)

Fig. 11.—Type Ears of Varieties: (40) Hickory King (Tennessee); (41) American Queen; (42) Parker's Cocke's Prolific; and (43) Bradbury's Improved.

have been due largely, if not entirely, to the effects of cold east winds prevailing during August of this year, and which brought all the varieties to premature maturity.

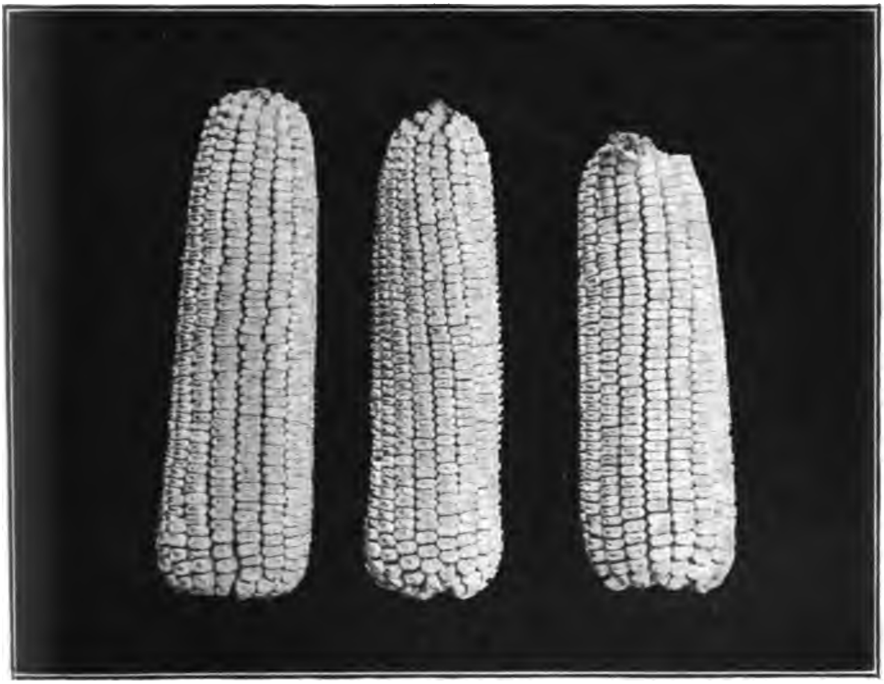
SOME LARGELY CONTROLLABLE FACTORS AFFECTING YIELD.

To secure large yields in any locality it is essential that good seed, a productive soil and proper tillage be supplied. By the neglect of any one of these factors it is absolutely impossible to secure a maximum yield, as this is determined, not by the most favorable factors, but by those essential ones present in the least-suited form for normal plant growth, just as the strength of a chain is gauged, not by its strongest, but by its weakest link. Some of the controllable factors involved in these three essentials will be discussed below. That portion of our subject pertaining to the soil, its fertilization and cultivation will be deferred for a subsequent bulletin, and will be taken up in discussing the results of fertilizer experiments which have been conducted on the Station Farm during the past few years. Only those phases of the subject pertaining to seed will be touched on which are not discussed elsewhere in this Bulletin. The farmer who gets most out of, or the one who suffers least from uncontrollable factors, such as lack of sufficient temperature and rainfall, is the one who regulates the controllable factors most intelligently.

Earliness in Maturity.—Except for the more elevated portions [illegible] the mountain region, or under circumstances in the other portions of North Carolina necessitating late planting, those varieties of corn producing the largest yields have been found to be those which mature at a medium to late date. Under certain conditions the early maturing varieties may be the largest yielders, but this is where the length of time for growth for some reason is not sufficiently long from planting to frost to mature those which require more time to complete their development; hence, when planted under these conditions, would suffer material reduction in yield by being caught by frost.

It can generally be assumed that varieties, not only of corn, but other crops, which mature early will not be large yielders, for earliness and high yield are antagonistic characteristics. With many crops, however, earliness is more essential than heavy yields; especially is this so with trucking crops, for if they do not reach maturity early in the season the best prices are not obtained. Where for any reason the season for growth is short, the best of the early varieties will give the largest yields under the conditions, but the yield will be smaller generally than would have been produced by the best of the medium and late maturing varieties had the season been sufficiently long for their full development.

Seed Selection.—The more intelligently and persistently field selection of seed is carried on, the larger the yield of corn from such seed will be. Within limits, the number of ears borne by any variety of corn is within the power of any corn grower to control, if proper methods of seed selection are used to supplement good soil and cultivation. One of the best yielding varieties grown in this State and tested is Biggs' Seven-ear; it is also the most prolific variety thus far found. Prolificacy is a largely controllable characteristic of the corn plant, which is associated with high yield, as is evidenced by most of our best yielders being of this type. On account of lack of appreciation of the possibilities for the improvement of yields by the use of good seed, selected from the field in the best manner, many farmers have not secured near the production per acre which their farms are capable of producing with the cultivation and fertilization which is usually bestowed. The matter of distancing rows and plants in the row, and of the effects of removing suckers from the plants, is also reserved for discussion in subsequent bulletins. It might be interesting to note here that the tendency to produce suckers seems to be largely a varietal characteristic.



(44) (45) (46)

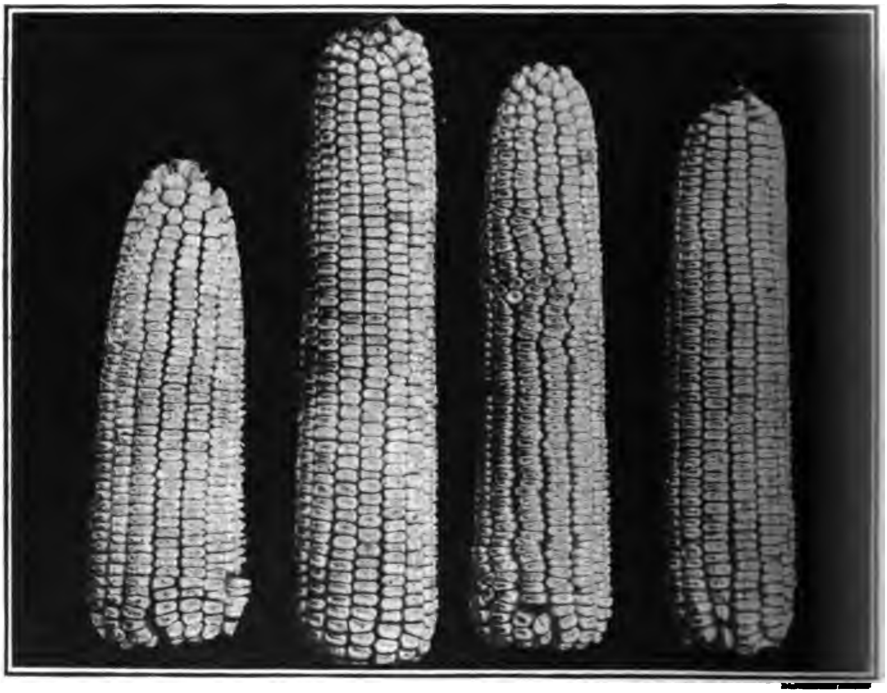
FIG. 12.—Type Ears of Varieties: (44) Boone County White (Tennessee); (45) Boone County White (Indiana); and (46) MacMackin's Gourdseed.

METHODS OF IMPROVEMENT.

At present there are three methods in common practice for the improvement of corn by seed selection, viz.: (1) importation or buying of improved seed; (2) field selection of the best home-grown seed, and (3) home field selection and growing of corn for seed purposes in an isolated field.

IMPORTATION OF SEED.

Under no circumstances should farmers depend each year upon importation for seed, as corn brought from a distance (where soil and climatic conditions are different) seldom yields satisfactory results until it has become thoroughly acclimatized, which usually requires from two to three years. The force of this statement is amply illustrated in our experience with the best varieties of Western and Northwestern corn. None of these have done extra well under North Carolina conditions the first year after importation, although they are among the most prolific ones grown in the principal corn-growing belt of the country. This further emphasizes the need in all variety tests of as complete knowledge as possible of the conditions under which the parent plants were grown. Especially should the locations be known from whence all seed come, before one can properly interpret varietal results; for, if not acclimatized, suppressed yield may be expected from this cause.



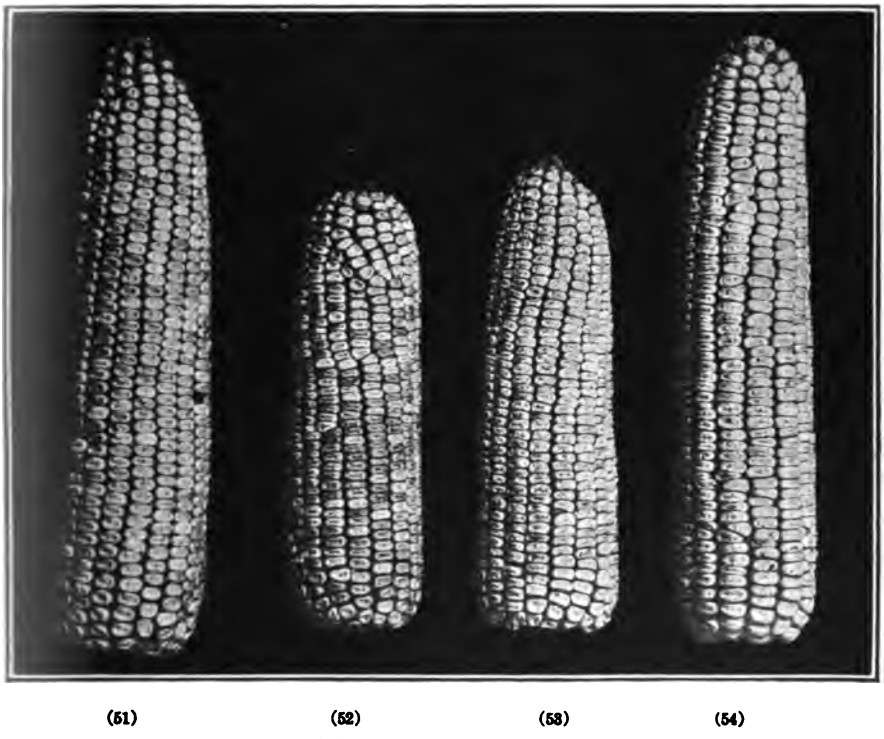
(47) (48) (49) (50)

FIG. 18.—Type Ears of Varieties: (47) Southern Beauty; (48) Eureka; (49) Mosby's Prolific; and (50) Sanders' Improved.

The advantage of imported seed is that the farmer is frequently enabled to begin improvement where some careful grower or skilled plant breeder has left off. It is here as with animals; for, if it is desired to breed milk cows, it is not best to go back to the "scrub" to begin selecting the desirable animals, but rather to begin with some of the best of the recognized milk breeds, like the Jersey, Guernsey, etc., and with these continue the improvement by breeding and selection.

Buying Seed.

In buying seed it is usually safest to secure seed in small quantities first, and from as near home as possible, other things being equal, and give them a trial before making extensive planting of the variety. This can be done, as some of the best yielders for North Carolina soils thus far found are those which have been originated in this and adjoining States. If a neighbor has better field-selected corn than you have, by all means secure some of his seed, as it will be found generally that his corn will do better in that particular neighborhood than corn bought at a distance. It is suited to the local conditions, as is evidenced by its superior yielding qualities. Farmers, in purchasing seed corn at a distance, should require the dealers to ship it on the ear and supply a statement as to where it was grown. This is essential, for, as pointed out above, if the corn was grown under greatly different soil and climatic conditions from those under which it is to grow, the seed will seldom prove satisfactory for at least the first two or three years, although they may be of strong vitality, good quality and come from an excellent variety, produced by a careful, conscientious grower. Another advantage of buying seed on the ear is that when it comes if it is not satis-



(51) (52) (53) (54)

FIG. 14.—Type Ears of Varieties: (51) Reid's Yellow Dent; (52) Riley's Favorite; (53) Iowa Silvermine; and (54) Selection 77.

factory it may be returned to the shipper, or if only a few ears are unsatisfactory they can be easily thrown out before shelling. It is best, in shelling seed corn, that each ear be shelled separately into a pan or bucket before putting with others, so that ears with undesirable characteristics may most easily be discarded.

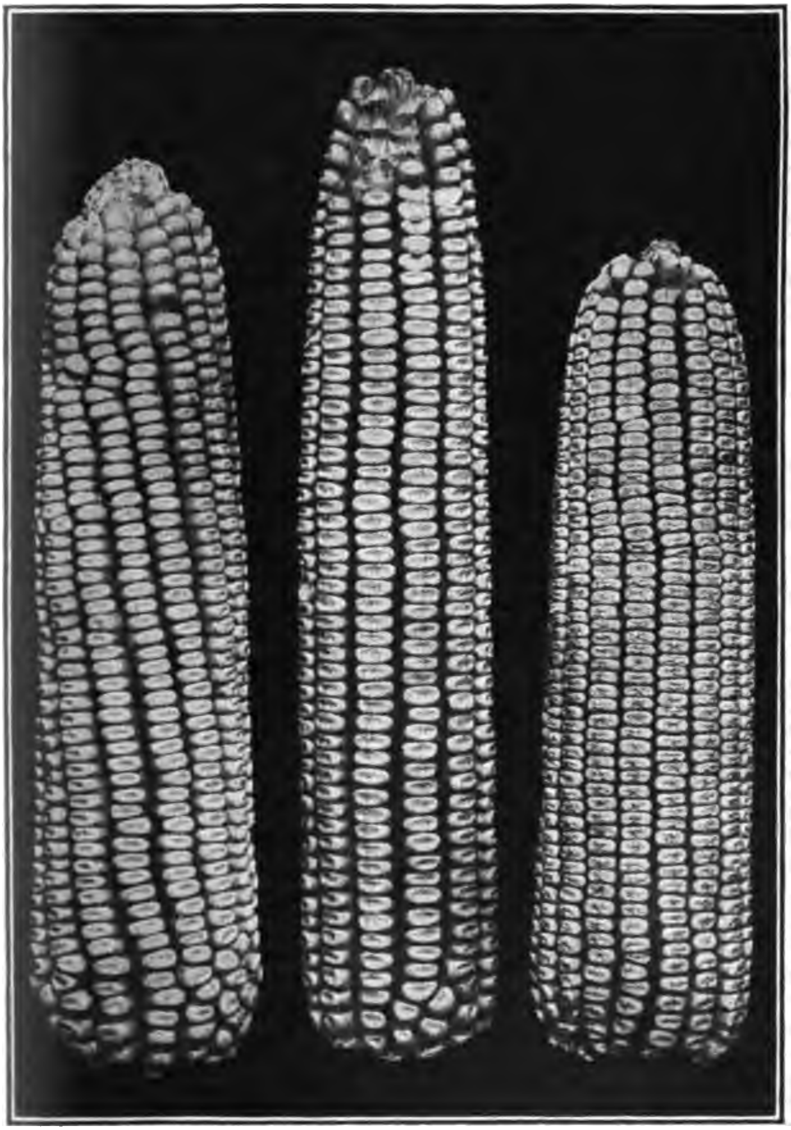
It is not always cheapest to buy the seed corn that can be purchased for the least money. In the tests of the Station, differences of five to ten bushels of shelled corn per acre between the yield of different varieties are of no uncommon occurrence. Now, assuming an average difference in yield of seven bushels per acre between two varieties, and placing seed of the poor-yielding one at 70 cents and seed of the best field-selected one at $2.10 per bushel, and assuming that a bushel of corn will plant seven acres, it will make the seed of land planted to the poorer grade cost 10 cents, while the planting to seed of the better variety will cost 30 cents per acre. Now, deducting the difference in the cost of seed for planting an acre to each of these varieties, a gain of $4.70 in favor of the use of the better seed is shown when the excessive yield of this is calculated simply at the market price of ordinary corn.

On the other hand, because a variety is advertised in extravagant superlatives and quoted at an advanced price, it is not always a guarantee of its worth. Hence, the best method to pursue in purchasing seed corn is to buy only from the most reliable parties and have it shipped on the cob, so as to enable the buyer to see just what he is getting. This precaution is advised because it is a well-established fact that many seedsmen buy whole surplus crops of corn and, without a particle of selection, other than removing rotten ears, shell and screen it and place it upon the market, after thoroughly advertising it, at a price many times the market price of ordinary corn, and often it is no better and sometimes decidedly inferior.

In buying seed corn on the ear do not expect too much, however, for it should be remembered that there are only a few prize ears in any field, and it would cost many dollars per bushel to get these out.

Acclimatization of Corn.

Other things being equal, it is not wise generally to import corn from a distance, especially a different latitude, because it will not, as a general rule, yield satisfactory returns until it has become thoroughly acclimatized, which usually requires from two to three or more years. We have had many striking instances of this fact in our tests of varieties of corn brought from the Northwestern States. None of these varieties have done very well with us, although they are the most prolific ones in the Northwest. This is the reason that it is urged, in another part of this Bulletin, that the history of all seed corn purchased be ascertained from the dealer. Neither is it prudent to buy seed corn that was grown in the extreme South, for it, being accustomed to a longer growing period than we have in North Carolina, will be liable to be caught by frost and thereby give a diminished yield of immature grain, especially if cool weather comes early in the fall. The small yield of the Northwestern corns, on the other hand, being accustomed to a shorter growing period than we have, is led to mature at an earlier period than is conducive to the largest yields in our climate.



(1) (2) (3)

FIG. 15.—Poor and Well-shaped Ears: (1) Too much space between grain-rows and poorly filled at tip; (2) Ear undersized; and (3) Well-shaped ear.

FIELD SELECTION OF SEED.

The proper place to select seed corn is in the field, at or just before gathering time, and select from stalks that have the most shelled corn per stalk, as such seed will tend to produce an increased yield in the next year's crop. Any method of seed selection that does not take the plant as a whole into consideration is not going to lead to the best results; for the stalk and leaves, which are the manufactory of the plant, determine to a considerable extent the size and quality of the ears. In all our results it has been observed that those varieties which have generally been the best yielders are those which produce more than one ear per stalk. Ears of medium length and size are preferable to the long and large ones, because the latter were generally either produced on stalks that bore but one ear, or else on stalks that grew on some fertile spot in the field, either of which seed do not tend to promote the greatest yields when planted. Seed from corn grown on average land will do better planted on land of medium fertility than when seed from corn grown on rich land is used, for the same reason that stock accustomed to poor conditions will do better on an inferior pasture than stock accustomed to more favorable surroundings.

The selection should not be turned over to the hired man, but should receive the best efforts of the farmer himself, as it is sure that time expended in this work will prove as profitable, if not more so, than any other work done on the farm. By continually selecting and planting corn possessing certain desirable characteristics, such as production of two good ears per stalk, it will be found, as the selection goes on from year to year, that these desirable qualities have each year become more thoroughly fixed.

It should be constantly kept in mind that on every farm changes, beneficial or detrimental, are continually taking place, as it is an inherent tendency of all plants to vary more or less and retrograde or revert to a less prôductive state if intelligent and rigid selection is not persistently kept up.

In making selections in the field, at least three to four times as much corn should be gathered as it is desired for seed purposes the following year, so that further and more careful selection can be made after the ears have been taken to the barn and when a leisure time presents itself. In the final selection the ears should be arranged conveniently on the barn floor or ground, and with an ear of the type desired in mind or in hand, go over the lot and remove all undesirable ones. The seed thus selected should be transferred to a box or barrel and covered with wire gauze or something else that will permit of thorough ventilation and keep out rats and mice. Store the barrel or box in some dry place and let remain until the seed are wanted for planting.

UNIFORMITY IN HEIGHT OF EARS.

If all the ears in a field are of approximately uniform height, there is greater probability of complete fertilization and filling of all the grains of the ears than would be the case if some of the ears were high up on the stalks, while others were comparatively near the ground. An extremely high ear tends to late maturity, while one very near the ground tends to ripen early, hence will not make, as a general rule, a very large growth. For the ears in a field to be completely fertilized or pollinated, the silks of the ears should be ready to receive the falling pollen grains (dust-like particles) from the tassels as soon as they begin to be disseminated by the wind.

BARN SELECTION.

It is a common practice with many farmers of North Carolina to make seed-corn selection from the crib in the spring, just before planting time, when the quantity is small and the quality inferior. This method yields better results than no selection at all, but is far inferior to field selection, where the performance record of each stalk may be given consideration.

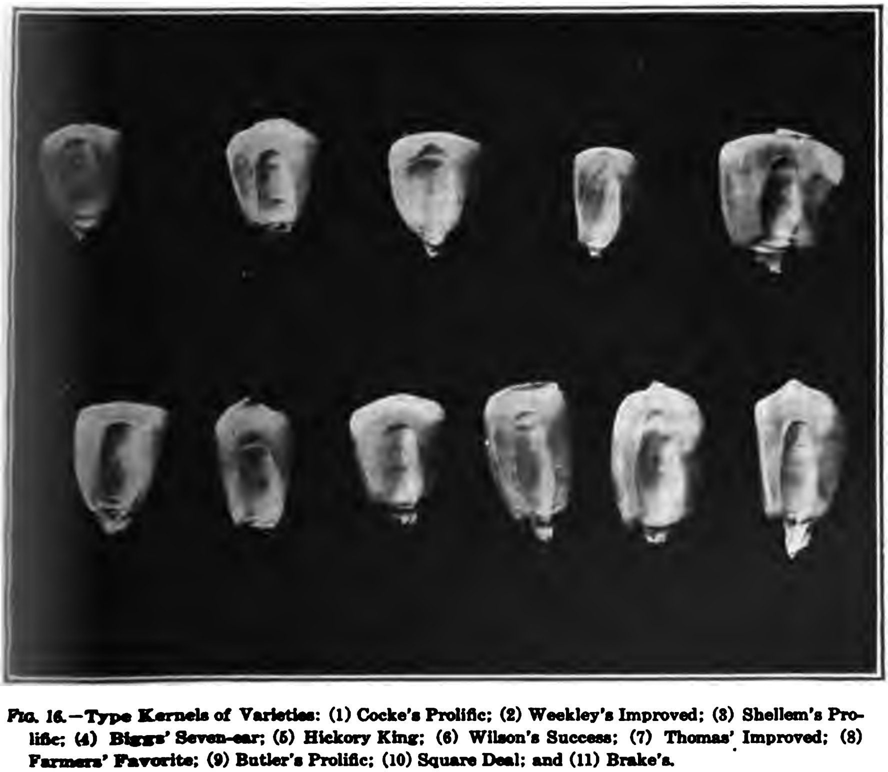


FIG. 16.—Type Kernels of Varieties: (1) Cocke's Prolific; (2) Weekley's Improved; (3) Shellem's Prolific; (4) Biggs' Seven-ear; (5) Hickory King; (6) Wilson's Success; (7) Thomas' Improved; (8) Farmers' Favorite; (9) Butler's Prolific; (10) Square Deal; and (11) Brake's.

In barn selection it is usually the larger ears that are chosen for seed purposes, and these are not generally, as pointed out above, the best ones for seed. We have in this State, by our barn method of seed-corn selection, been unconsciously selecting, growing and perpetuating types of corn of low prolificacy.

RESULT OF PROPER SEED SELECTION.

By careful seed selection the yield for North Carolina could easily be increased two bushels of shelled corn per acre, which would be worth about four million dollars per year clear to the farmers of the State when corn is selling for 75 cents per bushel. By adding one kernel per ear to the present yield, through the use of better methods of seed selection, from $75,000 to $100,000 annual increase would result in net receipts for the corn crop of the State. These are exceedingly low estimates of what might be done by the use of proper methods of seed selection, for the writer, as well as workers in other States, have found that from five to ten bushels of shelled corn more are yielded per acre from well-selected seed than from those selected by a less intelligent method.

FIELD SELECTION AND GROWTH OF SEED IN AN ISOLATED FIELD.

By carefully selecting a limited number of the very best obtainable seed ears from the field in the fall and planting them in a field separated from any other corn, something like 500 to 600 yards, to prevent crossing by the pollen being carried by the wind, much better and quicker results may be secured than where simple field selection from the general crop alone is practiced, *i. e.*, if the breeding plat is properly cared for. This plat should be tolerably fertile (equal at least to the lands on which the general crop is to be grown), for poverty of soil is very conducive to reversion, thereby losing in one year's growth on a poor soil much of what has been gained by a number of years of rigid selection. The rows in the breeding plat should be of such length that they will require only about three-quarters of an ear per row; and, in planting, each row should receive its individual ear, so that the performance record in yield of each seed ear can be seen, and if not satisfactory the whole row may be rejected for seed purposes. After planting as many rows as desired from the selected ears, a composite sample should then be made of the quantity of each ear left over, and a border of several rows planted entirely around the breeding plat to still further prevent the possibility of wind pollination from outside cornfields. The land on which this plat is to be located should be given deep and thorough preparation. The subsequent cultivations of the corn should be every ten to twelve days, with a cultivator with smaller hoes on, rather deep early in the season, but becoming shallower and with the larger hoes on as the season advances and the root system extends towards the middle of the row and nearer the surface. Especially is this important on upland soil, where conservation of moisture plays such an important part in yield. When the corn in the breeding plat has attained the tasseling stage the tassels from all barren stalks should be carefully removed just as they are emerging from the rolls of the last leaves. The tassel is the male part of the corn plant, while the silk is the female part. When the stalk is barren or bears only male organs the tassel is frequently above the average in size, strength and vigor, as all the vital forces of such a plant have been expended on this single organ of reproduction; hence, when an ovule or embryonic kernel, through the silk, is fertilized or pollinated by the yellow dust-like pollen from a barren stalk, it will, when planted, have a strong tendency, inherited through its male parent, to produce a barren or poor yielding stalk. The tassels should also be removed from all weak, diseased and otherwise stunted plants, for the same reason we would not use a "scrubby," stunted bull in a herd of cows if we cared anything for the future improvement of the stock. It has been demonstrated time and again by carefully conducted experiments that by selection from poor plants the yield of grain will not only be materially reduced, but will also be of an inferior quality. The writer has during the past six or eight summers visited a number of cornfields in different parts of the State, and has found but few fields that contained less than ten per cent of barren stalks, which means that from every ten acres in cultivation a loss of the yield of one acre from nonproductive stalks is generally sustained. It must not be overlooked that the secret in successful corn growing consists in having a good stand and in having each stalk bear at least one or two good-sized ears, as it costs just as much to cultivate nonproductive stalks or land without stalks as it does prolific ones and a good stand. The number of barren stalks in our fields should not, under average conditions of fertilization, weather and cultivation, ever reach over three to five per cent.

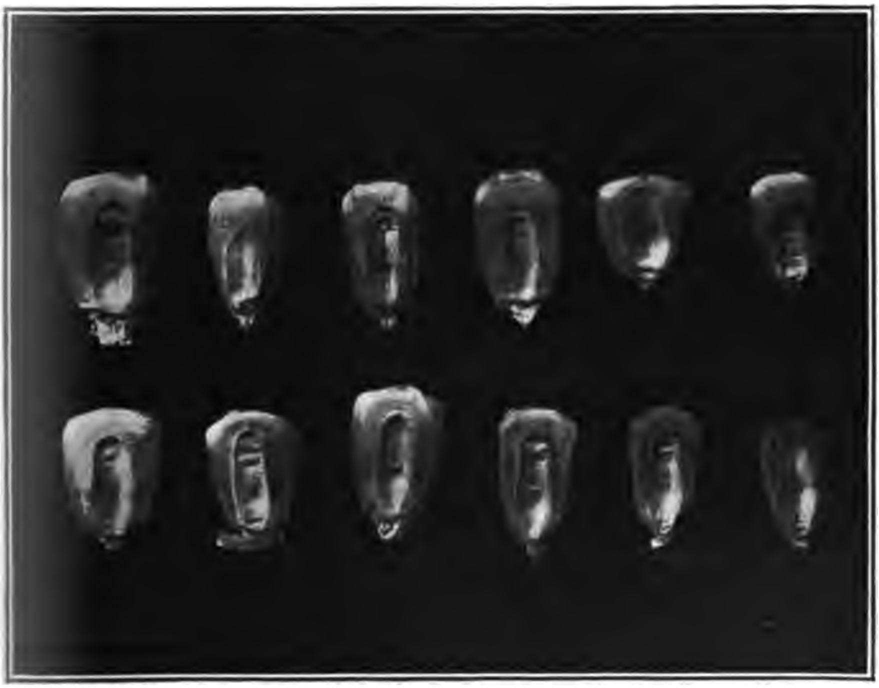


FIG. 17.—Type Kernels of Varieties: (12) Holt's Strawberry; (13) Mosby's Prolific; (14) Sanders' Improved; (15) Southern Beauty; (16) Eureka; (17) Hastings' Prolific; (18) Selection 77; (19) Iowa Silvermine; (20) Boone County White; (21) Reid's Yellow Dent; (22) Riley's Favorite; and (23) Leaming Yellow.

CHARACTERISTICS TO CONSIDER IN SEED SELECTION.

As total yield of shelled corn per stalk is the principal consideration in the production of corn, the following characteristics correlated with large yield will be taken up somewhat in detail for consideration:

PERCENTAGE OF GRAIN.

Although it is essential for any variety to possess the characteristic of producing a high percentage of grain to ear for it to attain its maximum yielding capacity, yet, as other factors, such as prolificacy, size of ears, source of seed, etc., enter, the largest yields need not necessarily be expected from those varieties possessing the highest percentage of grain. As a matter of fact, the largest yields by varieties tested at the Station farm during the past five years have been secured from those which produce a medium percentage of grain; but this is not because this is an unessential of the highest possible yields, but rather due to the fact that varieties possessing the highest percentages of grain have been bred and selected largely for this quality alone, while other characteristics that might have contributed to the yields were seemingly left out of consideration to a large extent in the establishment of these varieties.

The best yielding varieties have been found to bear ears which shell on an average of eighty to eighty-seven per cent grain. With the same variety there is a seasonal variation of a fraction of a per cent to two to four per cent, or even more.

Of the varieties thus far tested, Dodson's Prolific Shoepeg, Hickory King, Sanders' Improved, Craig's Prolific Strawberry and Craig's Prolific White have been found to possess the highest percentage of grain to cob. One hundred pounds of the ears of each of these shell from eighty-five to ninety pounds of grain.

HEIGHT OF EARS AND STALKS.

The best yielding varieties when grown at the Station have been found to be those which have a medium to tall stalk and which bear their ears at a medium height. The varieties possessing the lowest stalks and ears are those which have come from the corn-growing States of the Northwest. Cocke's Prolific, Mosby's Prolific, MacMackin's Gourdseed, Sanders' Improved and Eureka have shown up as some of the tallest growers and are varieties which bear the ears at an average height, a little less than one-half the height of the stalks.

NUMBER EARS PER STALK.

In variety tests on the Station farm during the past six years, as it has been found to be a pretty general rule that those which have averaged the largest yields of grain per acre were those possessing a decidedly strong tendency to produce more than one ear per stalk, it would seem to be safe to infer that the prolificacy of stalks in ears should be given consideration in selecting seed corn in the field. In the Station tests it has been found that Sanders' Improved, a fairly prolific variety, has yielded as an average of five years 6.8 bushels more of shelled corn per acre than Holt's Strawberry, a good one-eared variety; while Biggs'

Seven-ear, another prolific variety, has outyielded Holt's Strawberry 4.4 bushels as an average of three years' tests. Ordinarily, for the better grade of improved farming lands of the State, it is not felt that it would be wise to select seed from stalks bearing more than two ears. It is believed that the richer the land on which the corn is to be planted the greater the prolificacy in ears that may be selected with profit. On the poorer grades of land it is suggested that, until its yielding capacity has been increased, the best one-eared varieties be grown. Too great a prolificacy of corn to be planted on poor land may be a positive detriment to yield. The tendency of such seed will be to produce a large number of ears; and as the limited supply of available plant food contained in the soil will run quite low towards the latter part of the growth of the plants, there will usually be a large number of shoots and nubbins produced and very few ears; while on the other hand a one-eared variety might have given fairly good-sized ears under the conditions; certainly it would in all probability have done better. It might be stated in this connection that, where these conditions of soil obtain, it is thought that time might be put to better advantage in growing on it soil-improving

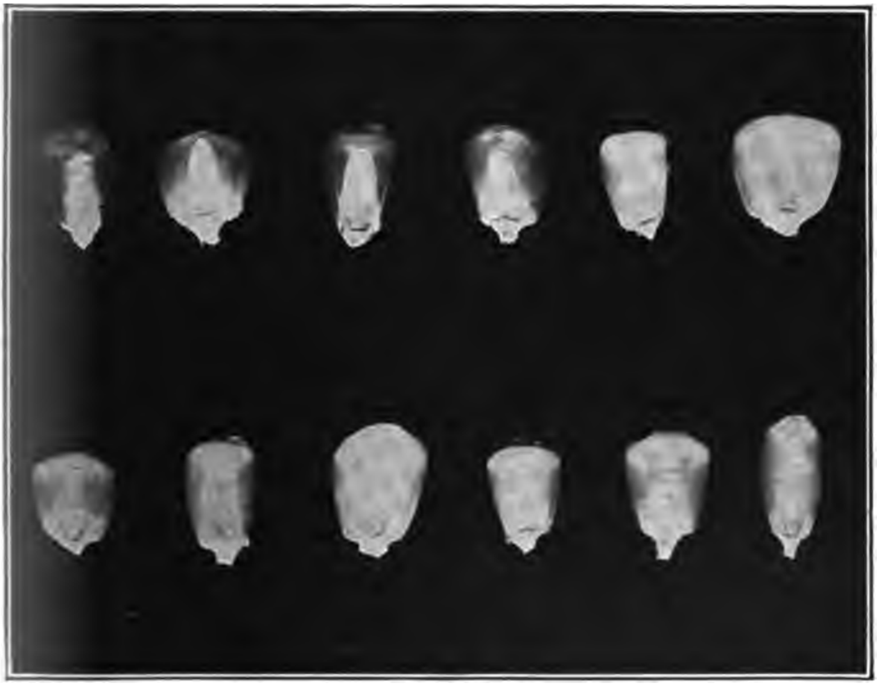


FIG. 18.—Type Kernels of Varieties: (24) Kansas Sunflower; (25) Jones' Yellow Dent; (26) Hildreth's Yellow Dent; (27) Wyatt's Improved Yellow; (28) Sharber's; (29) Hickory King (Virginia); (30) Culpepper's Extra Prolific; (31) Goodman's Prolific; (32) Columbian Beauty; (33) Jones' White; (34) Wright's Improved; and (35) Dodson's Prolific Shoepeg.

crops, such as cowpeas and clover, and defer planting it to corn until it has been considerably improved in producing capacity. It is not felt that corn can be raised profitably on very poor land.

WHICH OF TWO EARS TO SELECT.

In the selection of seed corn from stalks bearing two or more ears per stalk the selections should be made from those stalks that have the ears of a uniformly convenient height for gathering and of those ears on the stalks that possess the greatest number of desirable characteristics. Most investigators in this country who have made careful field tests and kept accurate records with this cereal are pretty uniformly of the opinion that the top ear, being usually the largest, best-shaped and matured, is the one, as a general rule, to be preferred for seed purposes. However, with present knowledge on the subject, it will be well to select for seed all the ears on stalks bearing two ears per stalk, if the ears are well shaped and thoroughly matured and possess kernels of proper shape, color and vitality. For practical purposes it is felt quite strongly that this procedure will likely prove the most rational. It must be kept in mind that if it is wished to produce a variety that will bear more than one ear per stalk, selection should be made in the field each fall from stalks bearing two or more ears. What is meant by a two-eared variety of corn is, or should be, that when it is grown under the same conditions as other varieties, such as Holt's Strawberry, Southern Beauty, or Eureka, it will have decidedly more stalks bearing two ears than these one-eared varieties. Of course, other factors besides seed selection play an important part in determining the yield of any variety of corn. They are fertility and physical condition of the soil, season, cultivation, etc. Notwithstanding these facts, some seedsmen advertise that they have certain varieties of corn that will bear two, three, four, five and even six and seven ears, as the case may be, per stalk, implying, if not stating positively, that the exploited varieties with euphonious and "catchy" names will do these wonderful and impossible things regardless of poverty of the soil and unfavorable soil and seasonal conditions. It is often wise to let your neighbor do the buying from the man that claims too much, and do your own purchasing from one that claims less and supplies seed that do more.

LARGE VERSUS SMALL EARS.

Although, taking everything into consideration, where corn is gathered by hand in the ordinary way, it will usually be a little easier and slightly cheaper to gather and handle the same acreage of large-eared corn than of corn with smaller ears, when the yield of shelled corn per acre for both are the same; yet, quite frequently, from a financial standpoint, it will be better for the farmer to use seed of a variety possessing a relatively small ear, because of the greatly increased yield of grain per acre that would result from the use of such seed. Within reasonable limits, it should not be so much the size of the ears that should govern in the selection of a variety for seed purposes as the persistency of the seed of the variety to withstand adverse conditions and to produce large yields of shelled corn per stalk, and hence per acre. However, in selecting within the same variety it will usually be advisable to choose for seed those ears, other characteristics being equal, that are of the average or slightly above the average in size for the variety.

The size of the ear of a variety is not determined solely by heredity, but is greatly influenced by climate, season, soil, fertilization, cultivation, etc.; for the more favorable these conditions are for the growth of the plants, the larger will the ears produced be at maturity; and the more unfavorable these conditions are, the smaller they will grow. In other words, if seed of the same variety were planted during the same year on both rich bottom and ordinary upland soils, it would be found at maturity, with a favorable season, that the corn grown in the bottom had not only produced a larger yield and greater number of ears per stalk, but had also borne considerably larger ears, and it would generally be easy for one who is at all familiar with ear types of different varieties to determine by general appearances whether a given ear had been produced on rich land or not.

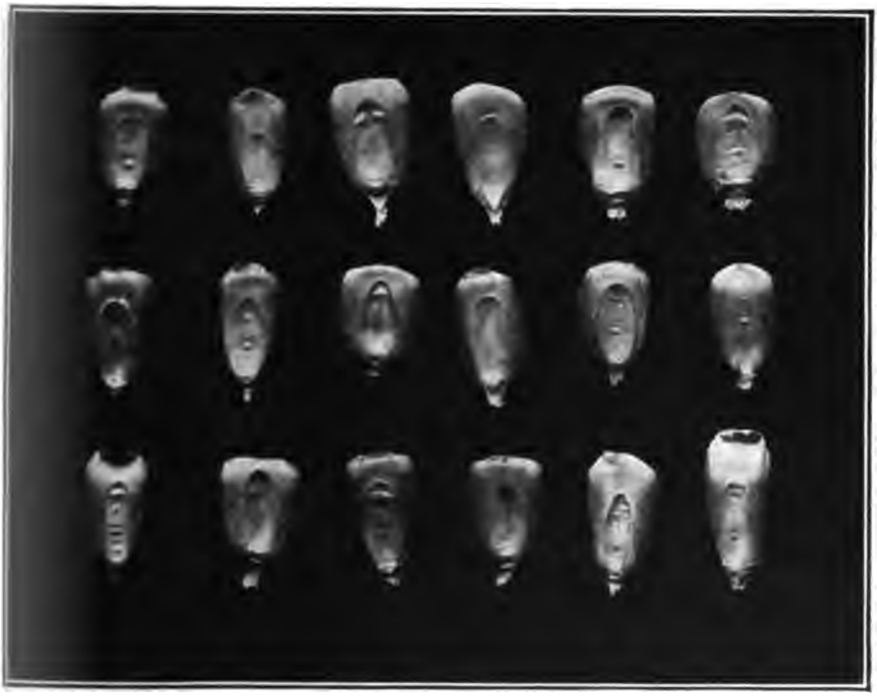


FIG. 19.—Type Kernels of Varieties: (36) Cleckler's Improved; (37) Bradbury's Improved; (38) Fry's Improved; (39) Cooper's Improved; (40) MacMackin's Gourdseed; (41) Pool's; (42) Harris' Improved; (43) Peele's Prolific; (44) Williams'; (45) Fredonia's Pride; (46) Cleveland's Pure White; (47) Jackson's Whitecap Prolific; (48) Krimminger's Improved; (49) Whelchel's Dent; (50) Osborne; (51) McAuley's White Dent; (52) Henry Grady; and (53) Horsetooth.

It will be better to use seed of a variety having medium small ears with poorly shaped kernels in preference to one with large, well-shaped ears possessing well-formed kernels, if the former produces, under the same conditions of season, soil and cultivation, greatly increased yields over the latter, notwithstanding the fact that it may be a little less expensive to house the latter, because the net profit resulting from the former would be much greater.

By using a variety with a strongly fixed prepotency to high yield of shelled corn per stalk, the great desideratum, after all, the size and shape of the ear and its kernels, may be materially improved within a few years, through careful seed selection, with a resulting tendency to further increased yields over the original stock. It should be borne in mind clearly, however, that by developing better-shaped ears and kernels of any variety, through seed selection, persistently practiced through a number of years, that only two of the many characters that contribute to high yields are improved. The greatest underlying cause of high yields, outside of environment, is a reasonable prolificacy.

STALKS.

The kind of stalk from which to make selections is one possessing a tolerably large circumference at the base and gradually tapering towards the top, as this is the type that stands drought best, and is not as apt to be blown down as high, slender ones. In selection, weight should be attached to good root and leaf development of the mother parent, as all nourishment and growth are largely dependent upon the thoroughness with which these two organs do their work. Poor root or leaf development is indicative of meager growth and small, poorly-developed production. All selections should be made from perfectly healthy plants.

EARS.

In selecting seed corn, care should be given to the following characteristics of the ear: position on stalk, kind of shank, shape and color of grain and cob, size of cob, filling out of butts and tips, number of and distance between rows of kernels, and length and circumference. The percentage of ear to total plant usually varies from forty to sixty per cent, with an average of about fifty per cent, when the corn is grown under fairly favorable conditions. The smaller the yield, the smaller the percentage of ear to stalk.

Position on Stalk.—If all ears in a field are of approximately uniform height, there is greater probability of complete fertilization of all the grains of the ears than would be the case if some of the ears were high up on the stalks, while others were comparatively near the ground. An extremely high ear tends to late maturity, while one very near the ground tends to ripen extra early; hence the stalks on which such ears are borne will not make, as a general rule, a very large growth. For the ears in a field to be completely fertilized or pollinated, the silks of the ears should be ready to receive the pollen of the tassels as soon as it is given off. On the same plant the silks usually make their appearance in four to five days after the tassel.

The position of ear on the stalk should be at a medium height, for two reasons: (1) because the stalk will be less liable to be blown down, as the ears will have less leverage, thereby averting the injury caused by

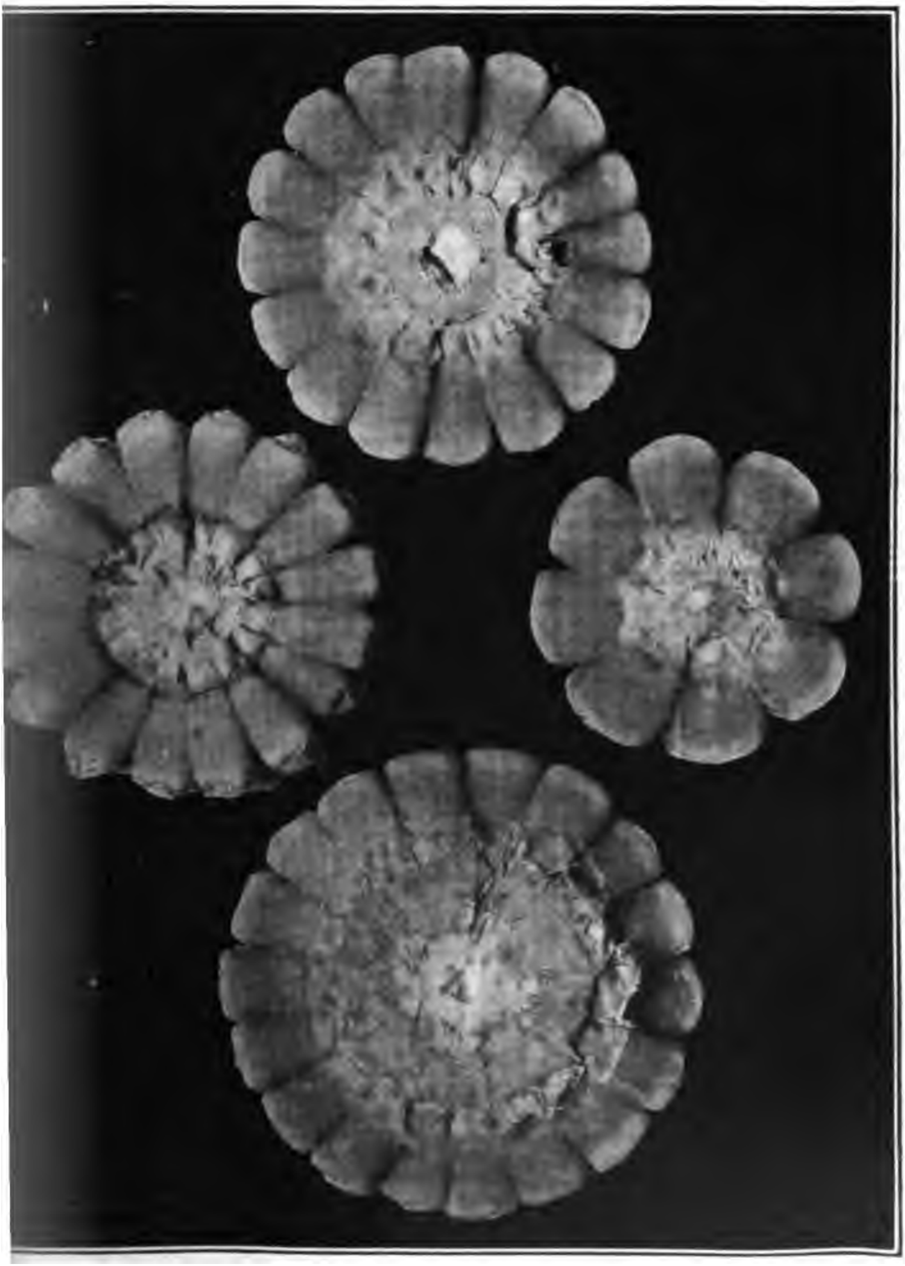


FIG. 20.—Type of Cobs: At left, ear has too large cob and kernels are too shallow; at right, well-formed ear with medium size cob, kernels are deep and wedge-shape; at top, kernels not of shape to fill well space between grain rows; at bottom, cob too small and kernels too shallow and round.

lying on the ground, and (2) because, if at a convenient height, it may be gathered with a great deal more ease and at considerable less expense, because the work can be done more rapidly.

Shank.—This should be of sufficient size and strength to hold the ear well and in a rather drooping position, so that rain will be shed and hence prevented from running into the ear and causing the grain to rot, as would often be the case if the ear were held in an upright position, especially if the end of the ear was not covered well by shuck.

Shape.—The cylindrical ear (Fig. 15, 3) is the best type, as it is the one that generally yields the highest percentage of grain to cob and the largest total amount of shelled corn per acre. The rows of kernels should run parallel the full length of the cob, without change in shape or diminution in size, or, if so, but very slightly. If the ears are tapering towards the tip, there is a suppression of yield, due to one or both of two causes, viz.: (1) diminished size of kernels at the tips; (2) dropping of rows of kernels an inch or so from the tip end.

Color.—Yellow corn should have a deep-red cob, while white corn should possess a white one, and any variation from these types is usually indicative of crossing varieties. The market price of meal or grits made from white corn with red cobs is generally lower, because the particles of the red cobs getting into the corn and being ground in with meal give it a reddish and unattractive cast.

Size of Cob.—A medium-sized cob is the best, because it usually yields the largest proportion of corn to cob. If the cob is small, of necessity the number of grain rows is restricted, and when large the proportion of corn to cob is reduced. The best size cob is shown at right in Fig. 20; the ear at left is too large, while the one at bottom is too small.

Length and Circumference.—The length to circumference should be about as 4 to 3, *i. e.*, if the ear is 8 inches long its circumference should be approximately 6 inches, when measured about one-third the way from the butt to the tip, in order to produce the largest yield. Too large circumference usually indicates small, narrow kernels, of low vitality and poor feeding value.

Filling-out of Butts and Tips.—The more perfectly ears are filled at butts and tips, usually the larger the percentage yield of corn. It is possible, by rigid selection of ears filled compactly at butts and tips, to increase materially within a few years the annual yield over corn in which no consideration is given to these characteristics. In Fig. 21 is shown poorly and well tipped ears.

Number of and Distance Between Rows of Kernels.—The number of rows to the ear should be comparatively large and the distance between them very small to secure the highest percentage yields. Wide *sulci*, or distance between rows, indicate reversion to an inferior type that it will not justify the farmer of to-day to grow. In Fig. 15 is strikingly shown the differences in the solid setting of corn on (1) and (3). In (3) there is little or no space between the rows, while in (1) there is considerable.

KERNELS.

The corn kernel may be divided into four parts: (*a*) the hull or outer layer; (*b*) the hard, flinty portion next to the hull and lying principally at the sides; (*c*) the white, floury portion occupying the crown, and (*d*) the germ or chit, which is situated on the side of the kernel, facing the tip of the ear. The hard, horny portion contains the larger proportion of the protein (flesh-forming material), while the white, floury part of the crown is rich in carbohydrates (which is the fattening and heat-producing portion of the grain, mainly starch), and the germ carries a greater part of the oil and is also rich in protein. In making seed selections for high percentage yields the kernels should be of medium wedge shape, but not too long and sharp, for such a form not only "wastes space at the cob and restricts the size of the germ," but indicates inferior quality and low vitality. The wedge-shaped kernel is the one that fills more compactly than any other the space between the grain rows. If the kernels are of fairly good shape, the percentage of grain of the ear should range from eighty to ninety per cent. The kernels having thin tips generally contain relatively low percentages of oil and protein and high contents of starch, and usually possess low vitality. The best shape is a plump tip, of about the same thickness as the upper portion of the kernel.

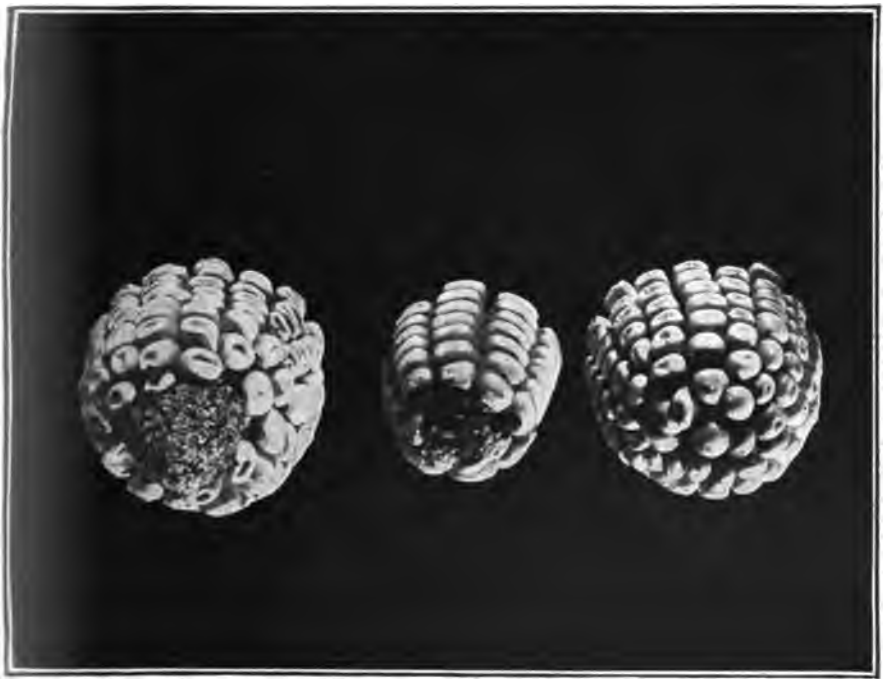


Fig. 21.—Well and poorly filled ears at tips.

In Fig. 20 are shown good and bad forms of kernels. The kernels on ear at right are of the best form, while those on all the other ears have some defects. Also, in Fig. 22 are shown fairly well-shaped kernels, which possess good germ development.

VITALITY OF SEED.

The vitality of any seed is largely governed by their stage of maturity when gathered, by the vigor of the parent plant, and by the care used in curing and storing them after harvest. As a general rule, with the same variety, the larger the seed, not only of corn, but all crops, the larger the amount of reserve plant food, and the higher the percentage of germination, and hence the better the stand. Low germination, resulting in a poor stand, is often one of the most potent causes for small yields. Large, plump seed are generally grown on strong, healthy plants. If possible, the seed corn should be gotten together and its germination thoroughly tested before planting time arrives. This can be done, after nubbing the corn, by taking three or four grains from different portions of the ears, putting them in moist sand in a plate, box or some other receptacle and placing in a warm place. The space in which the seed from each ear are placed should be marked in some way to correspond with the ear from which they were taken, and should be kept moist all the time, but not soaking wet. All the seed corn might be tested in this way with profit, and all those ears that showed a germination less than ninety-five per cent should be discarded. If the farmer cannot do this work himself, then he might interest his boys in it and let them do it. They will in all probability take great interest in this work, which may be done at night if necessary. This precaution is highly important, for, as a general rule, replants never amount to much, especially in the Piedmont and mountain sections of the State.

NUBBING EARS.

Carefully conducted experiments have demonstrated that it is advisable to nub corn before planting, for it has been found that, when seed from the tips and butts of ears are placed in one plat and by the side of it another is planted in kernels from the centers of the same ears, there is a larger percentage of dwarfed and barren stalks on the plat planted in tip and butt kernels than from the other, and hence less yield of shelled corn per acre. As both plats were planted on the same type of soil and treated in the same way by fertilization and cultivation, it is strongly probable that the decreased yield of the plat sown in butt and tip grains was due to the seed, as all other conditions were as nearly identical for both as it was possible to secure.

WHITE VERSUS YELLOW-EARED VARIETIES.

The Station, in its experiments, has secured higher yields of shelled corn per acre from the white than from the yellow varieties of corn. This greater yield may be due to the fact that the Southern people, being partial, as a general rule, to white corns, have improved them more than they have the yellow varieties. From the standpoint of chemical composition, the yellow corns are no richer in feeding value than the white ones, which fact is contrary to a common belief prevalent in this and other States. The only difference in the two is that there is a small amount of coloring matter present in the kernels of the yellow corn which is not found in the kernels of white varieties.

RELATION OF CHARACTERS.

One of the purposes of the detailed study of varieties of corn by the Station has been to ascertain what characters of this cereal, being mutually helpful and hence conducive to higher yields, may be expected to be found combined in the same plant or group (varieties) of plants, and what ones, being generally antagonistic to each other, seldom or never occur in the same plant or group of plants. This knowledge is highly essential in the development and improvement of corn, as well as all other agricultural crops; for if one is familiar with these fundamental facts he will be better enabled to originate, improve and select varieties best suited to his local conditions and purposes in the least period of time and with a minimum of disappointments. As an average of the results of the past eight years' work, supplemented by field observations, the tentative general inferences that follow are made with reference to the varieties of corn studied, when grown under conditions of soil and climate as represented by North Carolina.

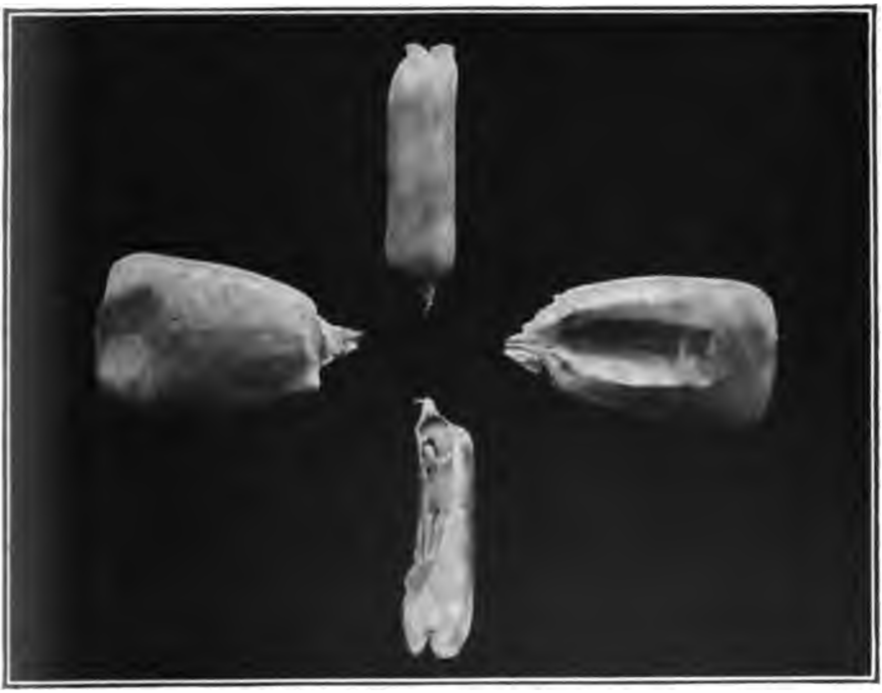


FIG. 22.—Well-shaped kernels, possessing large, strong, healthy germs.

ANTAGONISTIC CHARACTERS.

(1) Earliness in maturity, other things being equal, does not generally tend to large yields of grain and stover nor to high stalks and ears. (2) Large-eared varieties usually have a relatively low percentage of

grain to cob, and are, as a rule, less productive of shelled corn per acre, when grown under our conditions. (3) Ears with very small cobs have poorly shaped kernels, as a rule, and give a small amount of shelled corn per ear, and *vice versa.* (4) Kernels of low vitality do not tend to the growth of plants of maximum yields.

ASSOCIATED CHARACTERS.

(1) Earliness, other things being equal, usually tends to high percentage of ear to stover, and conversely, although this ratio is more or less modified by season, soil, fertilization, breeding and selection. (2) Varieties producing two ears per stalk are generally more productive of shelled corn per acre than those bearing only one ear per stalk, although it may be a large one. (3) Medium maturing varieties, in our experiments, have been the ones, generally, to give the largest yields per acre of shelled corn. (4) Small kernels usually possess low vitality, and those kernels with small germs contain a small percentage of fat or oil and reduced feeding value, especially for fattening animals. (5) Varieties with good root and leaf development are usually the most resistant ones to drought and insect and disease ravages. (6) The larger the yield in grain of a variety, the larger the percentage of ear of total plant, the heavier the grain by measure and the less pounds of ear corn is usually required to shell a bushel. (7) The smaller the yield per plant of the same variety, the smaller the number and size of ears and kernels, as well as the number of grain rows within quite narrow limits. (8) The higher the latitude or altitude under which a variety was originated, the larger the percentage the ear is of total plant. (9) Increasing the yield of any variety is attended by an increase in its prolificacy within narrow limits.

THIRTY-THIRD ANNUAL REPORT

of the

North Carolina
Agricultural Experiment Station

of the

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

for the

YEAR ENDING JUNE 30, 1910

Including

SCIENTIFIC PAPERS AND BULLETINS 205, 206, 207, 208

WEST RALEIGH, NORTH CAROLINA

RALEIGH
Edwards & Broughton Printing Co., State Printers
1911

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

Governor W. W. Kitchin, *ex officio* Chairman, Raleigh

C. W. Gold	Raleigh
E. M. Koonce	Jacksonville
T. W. Blount	Roper
D. A. Tompkins	Charlotte
J. T. Ellington	Smithfield
W. E. Daniel	Weldon
W. H. Ragan	High Point
W. B. Cooper	Wilmington
M. B. Stickley	Concord
T. T. Ballenger	Tryon
N. B. Broughton	Raleigh
O. L. Clark	Clarkton
Everett Thompson	Elizabeth City
R. H. Ricks	Rocky Mount
O. Max Gardner	Shelby
M. L. Reed	Asheville

STATION STAFF

D. H. Hill, President of the College

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist and Bacteriologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
G. A. Roberts	Veterinarian
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant Agronomist
B. J. Ray	Assistant Chemist
A. R. Russell	Assistant in Field Experiments
P. L. Gainey	Assistant Bacteriologist
L. R. Detjen	Assistant Horticulturist
F. W. Sherwood	Assistant Chemist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,

WEST RALEIGH, N. C., JUNE 30, 1910.

To His Excellency, William W. Kitchin,
Governor of North Carolina.

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1910.

Trusting that this report will prove satisfactory to your Excellency,
I am,
Yours very truly,
C. B. WILLIAMS,
Director.

TABLE OF CONTENTS

PAGE
Board of Trustees and Station Staff 2
Letter of Submittal 3

Reports of—

Director and Agronomist 5
Chemist 17
Vegetable Pathologist and Bacteriologist 22
Poultryman 24
Horticulturist 26
Animal Husbandman 27
Dairy Husbandman 29
Entomologist 31
Veterinarian 34
Financial Statement 35

Scientific Papers—

Studies in Soil Bacteriology 36
Three Interesting Species of Claviceps 52
Modification of the Diphenylamine Test for Nitrous and Nitric Acids 56
Notes of Plant Diseases Occurring in North Carolina 59
Some Breeding Experiments in Progress 73

Bulletins—

No. 21 (Press Bulletin)—Treatment of Oats, Wheat, Rye and Barley for Smu
No. 205—Insect Enemies of Cantaloupes, Cucumbers and Related Plants.
No. 206—Insect and Fungous Diseases of Apple and Pear.
No. 207—Hog Raising in North Carolina.
No. 208—Fig Culture in North Carolina.

THIRTY-THIRD ANNUAL REPORT

of the Director of the

N. C. AGRICULTURAL EXPERIMENT STATION

for the Year Ending June 30, 1910

By the Director.

During the year, the work of the Station has, as a whole, progressed fairly satisfactorily. Some old lines of investigation have been practically finished and many new ones inaugurated. It is believed that the activities of the Station are becoming more and more potent in the development of the agricultural industries of the State. An increasingly larger number of farmers are reading the bulletins issued on different economic subjects and are putting into practice the information which they contain.

Below is given a brief resume of the working of the institution, which is made up from the reports of the different workers and from the observations of the Director.

DIVISION OF AGRONOMY.

Much of the time of this Division has been devoted to work incident to the continuation of experiments in progress and previously reported. However, some new lines of work have been started and in some cases experiments previously reported have been more or less modified and extended in accordance with the light afforded by a study of the results of previous years. In the regular fertilizer series nine plots are set aside to study the effects upon the soil and yield of growing such legumes as crimson clover, bur clover, hairy vetch and cowpeas in rotation annually with corn and cotton under normal applications of fertilizer and with an application consisting of normal amounts of phosphoric acid and potash but no nitrogen. On practically all the fertilizer plots, a two-year rotation is maintained with corn and cotton, each of these coming in alternate years on the same plots. In these experiments the formula for the different individual plots does not change from year to year, but the proportion of the fertilizing constituents applied does vary depending upon whether corn or cotton is grown, as the normal application for the two crops is entirely different.

To determine the effects of different fertilizing constituents upon the yield and growth of corn and cotton, eleven plots are given over to a study of applications of incomplete fertilizer combinations; twenty to combinations in which the phosphoric acid, potash and nitrogen are used in varying relations; twelve to different quantities of normal mixtures; thirty-six to different carriers of nitrogen such as nitrate of soda, sulphate of ammonia, blood, cotton seed, stable manure, potash manure, beet refuse compound, calcium cyanamid and solubilized organic nitrogen applied at different dates with normal quantities of phosphoric acid and potash; four to normal applications applied all at planting in comparison with dividing and putting in one-half at planting and reserving the remaining one-half for a side dressing about the first of July; four to applications of lime every four years alone and in combination with normal amounts of phosphoric acid, potash and nitrogen at the rate of 1,000 pounds of slaked lime per acre broadcast; and six to different methods of applying normal quantities at planting. In addition to these, with cotton and corn, thirty-three plots are devoted especially to a study of the value of basic slag; twenty to finely ground phosphate rock; fifteen to Peruvian Guano as carriers of phosphoric acid for these crops. Sixteen distance and sixty-five variety-distance with corn and cotton are also in progress. In a study of varieties of different crops the tests embrace fifty-five of corn, thirty-nine of cotton, thirty-one of cowpeas, seventeen of soy beans, twenty-four of oats, fourteen of wheat, six of adsuki beans and two of seta beans. In the work with varieties of corn especial attention is given to a study of the relation that soil fertility, distance between stalks, production of suckers, manuring and prolificacy in ears sustain to each other and to yield per acre for each variety. Four one-quarter acre plots are being used to study the relative value for seed purposes and as yielders of (1) kernels from the tips, (2) kernels from the butts, (3) kernels from the middle of ears, and (4) all kernels together from the ears. Of the varieties of legumes thus far tested the best yielders of cowpeas have been found to be Whippoorwill and Small Black; and of soy beans, Mammoth and Haberlandt. In the tests last year, adsuki and seta beans did not yield as much seed as did soy beans planted under the same conditions, but they give evidence of worth as they produced more hay per acre than did the soy beans.

Selective breeding experiments are well under way with wheat and cotton. With wheat the experiments are planned to determine whether one careful initial selection followed by multiplication in the field is as effective in the improvement of wheat as continuous field selection, while with cotton cross-breeding of the best plants, bred from seed selected in the field from the most desirable parents, are used with the hope of securing strains of cotton of superior worth.

During the year, co-operative field tests with seven each of the best varieties of cotton and of corn have been started with twenty-one farmers located in different counties. The experiments are designed to apply the results secured by the Station to the different soils and sections of the State and to determine the value of seed of the most promising varieties of these two crops in comparison with the average seed and with seed of the best local varieties.

This Division is co-operating with the Bureau of Plant Industry in carrying on co-operative tillage experiments to determine the relative value of different methods of breaking and cultivating land for such crops as cotton and corn, and also in a study of the relative value of different varieties of cowpeas, soy beans, adsuki beans and seta beans from the standpoint of yield of seed and hay, vigor, date of maturing, habit of growth and power to hold leaves.

In the work on the production of suckers, embracing a study of fifty-five varieties of corn, many interesting and economic features are developing as the investigations progress. In these experiments, it has been observed that Sanders' Improved, Biggs' Seven-ear, Cocke's Prolific and Weekley's Improved varieties are all prolific and are the best average yielders of grain per acre.

Crimson clover alone or with oats and wheat; or oats, wheat or rye alone or with vetch are being used on practically all the Station farms as winter cover crops after cotton, corn, cowpeas, soy beans and small grains.

DIVISION OF CHEMISTRY.

The activities of this Division have been devoted largely to work in connection with investigations carried on to study the nature of nitrogen metabolism in the soil and the nature and cause of the toxicity of cottonseed meal when fed to swine. Efforts have been made to devise methods for the determination of the nitrifying and ammonifying power of different soils. Contrary to a belief long accepted as true, results have shown rather conclusively that there is absolutely no relation whatever between the ammonification and nitrification of soils in their natural state and in solutions. In the nitrification studies, which are being conducted in co-operation with the Biological Division, the Chemical Division has found many serious defects in recognized standard methods for the determination of nitrogen in its several forms which it has endeavored to overcome at the expenditure of considerable effort and time, by change or modification of the method or substitution of a new one. The diphenylamine test for nitrates has been so modified that it may now be used to detect one part of nitrogen in forty to fifty million. That portion of the investigation in soil bacteriology, pertaining more particularly to the bacteriological aspect of the subject, is referred to elsewhere in discussing the work of the Biological Division. During the year, 3,725 chemical determinations have been made in connection with this investigation.

In the cottonseed meal work this Division is co-operating with the Animal Husbandry and Veterinary Divisions. In connection with these investigations 445 chemical analyses have been made, and thirty-eight different kinds of extractive solutions from thirty-three different kinds of feeds have been prepared for feeding to pigs and guinea pigs, and injecting hypodermically.

Analyses have been made of the meal for different organic and inorganic substances, and of the extracts made by the more common chemical solvents. The liver, kidneys, bones and tissues of pigs dying from cottonseed meal poisoning have been subjected to chemical tests for the presence of zinc and copper. These were found in extremely small amounts, but not in sufficient quantities to be injurious. Neither was the presence of any other inorganic substance detected which might be the cause for the fatal results following the feeding of the meal. It has been found that the insoluble residues from all solvents tested is more or less toxic, and that the ash from the meal is harmless. In the light of recently published claims that the toxicity of cottonseed meal is due chiefly to the presence of a salt of pyro-phosphoric acid, a lot of the type of cotton seed claimed to furnish harmless extracts and meal from them which is toxic have been secured to further the investigational studies and to determine if in any way the form of phosphoric acid in these bears any relation to their toxicity when fed to swine.

DIVISION OF BIOLOGY.

The workers of this Division have confined their attention this year largely to the continuation of investigations previously mentioned. Although the laboratory work in connection with the lettuce drop investigations has practically been completed and the results put in shape for publication, it is planned to continue the field studies for a time largely in order to determine if practical eradication can be effected by methods based upon knowledge secured in the laboratory studies. Last year without the use of preventive measures, more than fifty per cent of the lettuce plants in the cold frames were destroyed before attaining a marketable size, while this year by observing certain precautions there was practically no evidence of the presence of the disease in the beds, as there were only three plants affected out of twelve hundred in the beds. As this disease entails thousands of dollars of damage to the lettuce industry of this and other States, the working out of practical methods for its suppression or control means much to the growers of this crop. The Division has continued a co-operative Plant Disease Survey of the State with the Bureau of Plant Industry on practically the same basis as reported in previous years. Apple canker, black leg of Irish potatoes, persimmon blight, ergot of paspalum and gama grass, and egg-plant wilt have been collected and studied in the laboratory under this survey.

The tobacco wilt investigations which are being conducted at Creedmoor have been much enlarged by entering into co-operative relations with the Bureau of Plant Industry. A field study is being made this year of twenty-nine selections from Italian, Sumatra and native types of tobacco. Last year the strains under experiment showed an average resistance to the disease of seventy-two per cent for the Italian and seventy-four for the Sumatra types. The progeny from three resistant native plants found in a badly infected field are being used to further the work this year. Fourteen plots have been put out on badly infected soil to study the effects upon the wilt of treatments with different fertilizing materials and chemicals combined in different ways.

This Division has continued its co-operation with the Chemical Division in soil bacteriological studies. Results secured in these joint experiments show that nitrification and ammonification do not take place in soils as in solutions and that the results obtained by the use of one medium can not be taken as an index of what will occur in the other medium. These studies have developed the fact that a large percentage of the soils of North Carolina possess little or no appreciable nitrifying power. The investigations have been extended to embrace small plot tests conducted under bacteriological control and designed to determine the acceptability of ammoniacal nitrogen in comparison with nitrate nitrogen.

The melon wilt experiments which the Division has been conducting co-operatively with the Bureau of Plant Industry have been continued. Seed of eighteen selections from resistant plants were planted this season. Last year not only a resistance of more than ninety per cent was secured, but most of the melons were of good quality and of marketable size.

During the year the section of a bulletin on the disease of the apple and the pear and their treatment has been prepared by the Biologist.

DIVISION OF POULTRY.

The work of the Poultry Division has been conducted during the year largely along the same general lines as previously reported. The studies in connection with the management of incubators and brooders and of various systems of feeding and care of young chicks and old stock is being continued.

During the summer in feeding different rations to twelve different pens of hens, it was found among other things that supplementing a mash consisting of equal parts of corn meal and wheat bran with a daily allowance of one-half pound of skim-milk per individual that this ration gave the cheapest production of eggs and the largest gains in weight, and brought the hens through the moulting period in better condition than any other of the rations fed. In the winter, although the cheapest eggs were secured from hens fed on cottonseed meal with the above mash, the largest profits per hen, however, were made from a ration in which a mixture of bone meal and meat meal entered into the corn meal and wheat bran mash as hens fed on this mixture laid a much larger number of eggs than did those fed on the ration in which cottonseed meal entered; hence more than making up in quantity what was deficient in cost per dozen. In all the feeding work it has been observed that hens have done better on a cottonseed meal ration than have pullets. It has not been possible thus far to induce the fowls to eat as much of the meal as was considered necessary for best results.

Lots have been provided in which to grow green crops for the fowls to range on. It is planned to have the crops come in succession and to conduct experimental feeding tests with different rations while the fowls are ranging on the growing crops. It is the aim that the succession of crops that will be worked out and used will be such as may be grown on most of the farms of the State, for it is felt that work along this line is fraught with great possibilities and economic value.

The Poultryman has in course of preparation for publication a bulletin giving the results secured in feeding tests by the Division with hens and pullets on many combinations fed under widely varying conditions during the past two years.

DIVISION OF HORTICULTURE.

The energies of the Horticultural Division have largely been directed along the line of investigations into the nature and cause of double flower in dewberries and blackberries. The work has been carried on simultaneously in the field and with the microscope in the laboratory with twenty-three varieties of blackberries and fifteen varieties of dewberries, and results secured during the year seem to indicate that a fungus is intimately associated with if not the cause for this abnormality of growth. In the light of these results, inoculations with the fungus always found present in affected plants, are being made into normal buds of healthy plants to determine if double flower can thus be induced. At the same time in the field, spraying experiments are being conducted to study the effects of different treat-

Google

ments upon the development of this trouble. Thus far double flower has developed only on the Wilson blackberry and the Lucretia dewberry, it being much worse on the former than on the latter. Wild blackberries in the neighborhood of the Station are usually badly affected with this growth.

During the year, the self-sterility experiments have been enlarged to embrace muscadine grapes in addition to blackberries and dewberries. In these investigations, an effort is being made by field and microscopic studies to determine not only what varieties are self-sterile and what varieties or types will be best to use to fertilize these self-sterile types, but to ascertain the cause or causes for this sterility. With the self-fertile varieties some work is being carried on to determine whether cross-pollination gives better results or not than self-pollination. Of the fifteen varieties of dewberries that are being worked with, it has been found that Premo, Chestnut, Manatee, White, San Jacinto and Rogers are self-sterile or practically so. With all the varieties of blackberries and dewberries under experiment, field observations are being made as to the flowering and fruiting periods of each as well as to the amount and character of berries produced.

With muscadine grapes the investigations embrace a study of the Scuppernong, James, Misch, Flowers and Thomas varieties. Many vines produced by cross-fertilization are now being grown in the green-house and field for the purpose of studying inherited characters.

Some work is being conducted to determine the cause or causes for the variations in the size of the clusters of grapes of the scuppernong. Also a study is being made of various methods of heading-in of young apple trees, and the conditions surrounding and the cause for the premature dropping of figs.

During the spring the Horticulturist prepared a Bulletin on fig growing.

DIVISION OF ANIMAL HUSBANDRY.

The Animal Husbandry Division, co-operating with the Chemical and Veterinary Divisions, has been engaged largely in aiding in carrying forward investigations planned to work out the nature and cause of the poisoning resulting from prolonged feeding of cottonseed meal to swine. A good many extracts and residues have been prepared, fed and the results carefully noted and recorded. During the year guinea pigs have been used chiefly for the experiments as it has been found that meal-feeding results equally disastrously when fed to them. Other advantages in their use are that they respond more quickly, require less financial outlay and entail much less loss upon death. Recent experiments have demonstrated rather conclusively that souring or cooking before feeding renders the meal less harmful to the hogs than when fed in the raw condition. A sow with an initial weight of thirty-three pounds was fed three hundred and twenty-six days on a cooked ration of cottonseed meal and corn meal, the cottonseed meal varying from one-half to two pounds per day, before death resulted. During the experiment the sow ate 414 pounds of cottonseed meal. Results indicate that cottonseed meal should not be fed to suckling pigs in any quantity or form as their growth is materially checked thereby. A combination of cottonseed meal and shelled corn in the proportion of 1 to 4 has proven to be a more efficient ration for hogs than linseed meal and corn in the same proportion; cottonseed meal and shelled corn in the proportion of 1 to 7; or corn alone. Experimental evidence is in hand to show that brood sows should not be maintained in too high a condition at farrowing time, for such a condition prevents normal delivery. The experimental feeding of cottonseed meal to horses and mules has continued through most of the year, and much valuable data with reference to the value of this concentrate as a supplementary feed to corn has been secured. The results seem to indicate that the meal may be fed with profit by farmers to their work stock if proper precautions are observed in its feeding. During the late fall and winter twenty-one mountain steers were fed experimentally at the Station farm. Cottonseed meal was used as the concentrate and a test was made of the relative value of cottonseed hulls, corn silage, and a mixture of corn stover and silage as roughages for beef-production. Although fairly satisfactory gains were made from all the combinations, the most economical ones were secured from those rations in which corn silage entered.

The experiments outlined to study the relative value of different green and root crops in continuous rotation for pork production are being broadened and continued. This work is being carried out on numerous one-half acre lots and the hogs are turned in and allowed to graze the crops at their pleasure. Everything considered, a mixture of Canada field peas and oats sown in the fall has afforded the most satisfactory grazing combination for hogs thus far tried.

For the grading experiment which is well under way, a pure Berkshire sire is used on a typical "razor back" sow. In this experiment an effort is being made to demonstrate the marked effects upon the progeny of breeding such a sow to a boar of good blood. It is planned to carry on this work through several generations and keep a complete set of photographic and other records. Something should be expected from these experiments that will have not only a scientific value but a practical adaptation.

During the year, a bulletin on hog raising has been prepared by the Animal Husbandman and published.

DIVISION OF DAIRY HUSBANDRY.

The dairy Husbandman has devoted much attention to experimental work in connection with the preparation, packing and shipping of cottage cheese and neufchatel cheese. The studies have embraced a determination of the best degrees of moisture and temperature at which to hold both kinds of cheese; the optimum percentage of cream to add; the value of pasteurizing cream or milk before adding to the cheese; the best kind of containers in which to place the products upon the market; and effects of storing under different conditions upon the keeping qualities of each.

In making the cheese pure lactic acid bacteria cultures have been used to hasten the curdling and draining of the cheese before foreign organisms can gain entrance and make much headway. The old process is open to the objection that through the slow souring undesirable organisms are given a chance to develop and hence the cheese frequently has an off flavor.

The method previously mentioned for the manufacture of cottage cheese has been greatly simplified and improved; and a new one for making neufchatel cheese has been devised.

The results of the feeding experiments which have been conducted with dairy cows to determine the relative value of medium and narrow rations for the production of milk and cream have been put in shape for publication. They not only indicate strongly the feasibility of feeding the narrow ration under Southern conditions, but strengthen the belief that in economical milk production the ratio of protein and carbohydrates should be varied not only with the flow and richness of the milk, but also somewhat according to cost of materials supplying these two classes of nutrients.

The cottonseed meal feeding experiments with dairy cows have shown that this feed has practically the same feeding value measured by milk and cream production, as linseed meal which costs about one-fifth more per ton. It has also been found in the experiments that cottonseed meal may be fed as one-third of the concentrate ration with corn silage to cows up to calving without ill-effects to either the cow or calf.

Feeding cottonseed meal to twenty heifers varying in age from six to eighteen months in quantities ranging from one-half to three-quarters of a pound daily per animal, in connection with equal amounts each of wheat bran and corn meal has given quite satisfactory results. The roughage, consisting of corn silage and cowpea-vine hay, was supplied in quantities which the calves would consume.

The investigations carried on during the year by this Division to determine what results follow the feeding of old pasteurized milk and skim-milk soured by pure lactic acid cultures have shown that scours are not induced by feeding either, unless the pasteurized milk is badly curdled.

DIVISION OF ENTOMOLOGY.

During the year this Division has devoted attention to life history studies of two species of melon worms. Field work was carried on during the fall and again resumed in the spring as soon as material appeared. Cantaloupes have been planted on the Station farm at different dates to supply the worms with material on which to feed throughout the summer. The field studies are being supplemented by those made on the worms under control conditions in a wire cage. The Entomologist spent some time during the early fall in webworm studies, but they did not make their appearance then in sufficient numbers in the vicinity of Raleigh to justify the taking up of systematic life history investigations. The results thus far secured seem to indicate that the webworm is unable to survive our winters successfully. Also the life history studies and field observations would lead to the belief that poison sprays will be effective against the attacks of this insect. The work which has been done with the harlequin cabbage bug has demonstrated that this pest can be controlled to a large extent by picking the adult bugs that appear early in the spring before they have deposited any eggs, and then treating those which appear later with kerosene emulsion.

A further study has been made of the effectiveness of spraying apple trees for San Jose scale with lime-sulphur wash and for codling moth with a solution of three pounds of arsenate of lead to fifty gallons of Bordeaux mixture.

Other insects studied are the apple woolly aphis, elm leaf beetle, wire worm, corn stalk borer, catalpa sphinx, flea beetle, Hessian fly and strawberry weevil.

During the year, the Entomologist has prepared a bulletin on cucurbitaceous insects and aided in the preparation of one on the insects and fungus diseases of the apple and pear. There is much demand by farmers for information with reference to insect pests and successful methods for their destruction or control.

DIVISION OF VETERINARY SCIENCE.

The efforts of this Division have been practically confined to co-operative investigations with the Chemical and Animal Husbandry Divisions designed to ascertain the nature and cause for the toxicity of cottonseed meal when fed to swine and guinea pigs. An attempt has been made to determine all the pathological conditions induced by continued feeding of the meal. Daily ante-mortem observations on the weight, pulse, temperature, respiration and the general condition of the pigs and guinea pigs under experimentation have been carefully made and recorded. With most of the animals post-mortems have been held and microscopic examination of the spleen, liver, kidneys and heart has taken place, and in a few instances observations have been made on the lungs, lymphatic glands, brain and spinal cord. Uniformly with the kidneys and liver, it was found that a marked congestion of the minute blood-vessels had taken place and that a condition known as cloudy swelling had developed which marked the beginning of degeneration. The heart showed much the same condition, but here it was neither so uniform or pronounced. When any alteration was observed in the spleen it was accompanied by an excess of blood corpuscles, indicating congestion. A good many blood readings have been made to determine the number and nature of the corpuscles; percentages of total solids and hæmoglobin; and the specific gravity of the blood of hogs fed cottonseed meal as a supplementary feed.

Macroscopically, the lungs have shown normal, congested, hepatized and œdematous areas, this being uniformly more common with the swine than in the guinea pigs.

The Veterinarian has devoted a small amount of time in co-operative work with the State Department of Agriculture in the preparation of hog cholera serum and in the use of this in a few outbreaks of this scourge in several herds in different portions of the State. The results have been such as to commend this treatment to more general use.

NEW BUILDINGS AND EQUIPMENT.

For fire protection and to meet the urgent demands at the farm, a 5,000-gallon covered cypress tank on a forty-foot galvanized steel substructure has been installed. To elevate the water from a 43-foot well into the tank for distribution to the different buildings and lots, a three-horse-power vertical gasoline engine, and suitable pump with jack with necessary piping have been provided. A tool and implement shed, 70 feet by 35 feet; four cattle pens; four colony poultry houses; a smaller shed to barn at poultry plant; scales and scale rack; and more than 1,000 yards of wire fencing have been put in place. A 40-bushel manure spreader, a feed grinder, two mules and a horse have been purchased during the year.

NEEDS OF THE STATION.

This Station is greatly handicapped by lack of funds which may be used for building purposes and for co-operative work with farmers. There is now great need for a large new barn, a comfortable house for the Superintendent to live in and other buildings for housing the stock and implements which are or should be at the farm. In the last published annual report of the Director of the Office of Experiment Stations to the Secretary of Agriculture he, among other things, stated: "The North Carolina Station is wholly dependent upon Federal funds for its support. In view of the restrictions surrounding the use of these funds, a supplementary State appropriation under less restriction is essential to the highest efficiency of the Station."

It is held that we can not use Hatch or Adams funds for paying the expenses incurred in any form of extension work, nor for printing except from the Hatch funds in printing results of experimental work which has been carried on by the Station.

Only $750.00 annually of the Hatch funds can be used for building and repairs. The average income of the Experiment Stations of the United States from sources provided by the several States is something like $20,000 annually. As North Carolina is not appropriating one cent, the North Carolina Station is not keeping pace, nor can it, with the advancement that is being made by other Stations of the Union located in States that are aiding the Stations by direct appropriation and in other ways financially.

BULLETINS.

Bulletins have been issued as follows:

No. 205.—Insect Enemies of Cantaloupes, Cucumbers and Related Plants, by R. I. Smith.

No. 206.—Insects and Fungous Diseases of Apple and Pear, by R. I. Smith and F. L. Stevens.

No. 207.—Hog Raising in North Carolina, by R. S. Curtis.

No. 208.—Fig Culture in North Carolina, by F. C. Reimer.

No. 21.—(Press Bulletin) Treatment of Oats, Wheat, Rye and Barley for Smut, by F. L. Stevens.

REPORT OF CHEMIST.

The work of the Chemical Division during the year ended June 30, 1910, has related mainly to investigations in soil bacteriology and to investigations as to the toxicity of cottonseed meal. Largely incidental to these main lines of work we have been led to the studies of the phenol disulphonic acid method for determining nitrates, of the Syme modification of this method, of the Tiemann-Schulze method for the determination of nitrates, of the Pickel condenser in ammonia determinations, of the Kellerman and Robinson method for estimating nitrification, of the composition of guinea pig urine, of the mineral matter in the viscera of swine, and have modified the diphenylamine test for nitrites and nitrates so as to make it very much more delicate.

In addition to these we have made several determinations, which may be classed as miscellaneous.

SOIL BACTERIOLOGY.

The work in soil bacteriology has been in co-operation with the Division of Bacteriology and has included the analysis of 1738 soils and solutions as follows:

Soils from Experimental plats	282
Soils from Experimental pots	58
Soils from Soil Survey of North Carolina	646
Soils from other studies in nitrification	682
Solutions for Soil Survey	42
Solutions for Nitrification studies	28
Total	1,738

The 3725 determinations involved in this work have consisted of the following:

Acidity	11
Volatile Matter	32
Humus	43
Nitrogen—Modified Kjeldahl	47
Ammonia by Magnesium Oxide	487
Nitrites and Nitrates—Diphenylamine	581
Nitrites by Griess Method	1,259
Nitrates by Phenol Disulphonic Acid	297
Nitrates by Tiemann-Schulze Method	968
Total	3,725

Articles entitled Studies in Soil Bacteriology II, III and IV have been published in the Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, and papers embodying the results of this work are submitted herewith for publication as a part of this report. A paper was read, embodying some of these results, before the North Carolina Academy of Science at its May, 1910, meeting.

TOXICITY OF COTTONSEED MEAL.

This work has been in co-operation with the Animal Husbandry and Veterinary Divisions. This Division has prepared 140 kilograms of feeding stuffs as follows:

23 kinds for ....386 guinea pigs
4 kinds for .... 8 swine
6 kinds of extracts for...... 13 rabbits

Total....33 kinds of feed for..........407 animals and
5 kinds of solutions for hypodermics for 30 guinea pigs.

The swine and the guinea pigs were fed by the Animal Husbandry Division and the rabbits by the Chemical Division. The hypodermics were administered by the Veterinary Division and all post-mortems were by the latter Division.

The analytical work has consisted of 445 determinations in 36 samples of cottonseed meal and its fractions, as follows:

Moisture	19
Ash	11
Complete Inorganic Qualitative and Microscopic analysis	5
Free hydrochloric acid	186
Sugar	26
Sulphur	2
Nitrogen	53
Phosphoric Acid, total	44
Phosphoric Acid, salt soluble	2
Phosphoric Acid, citrate insoluble	14
Carbon	4
Copper	9
Zinc	2
Manganese	2

PHENOL DISULPHONIC ACID METHOD FOR DETERMINING NITRATES.

This method is described in Bulletin 31 of the Bureau of Soils of the United States Department of Agriculture (page 39). We have made tests of this method, using solutions containing known amounts of nitrates and find that it is not very accurate. We also tried extracts of soil to which known amounts of nitrates were added and found that the method did not accurately show this difference. But notwithstanding its inaccuracy, we know of no better method for use in those cases in which only very small amounts of nitrates are present and so are using it.

The late Dr. W. A. Syme, formerly of this Division, published in the Journal of Industrial and Engineering Chemistry for March, 1909, (page 188), a method for removing organic matter from solutions. Our observations confirmed those of the author that the results are higher than those obtained by the old method. The analytical portion of this work consisted of the analysis of 80 samples with the following determinations:

Nitrates by Method of Bureau of Soils	146
Nitrates by Syme Modification	60
Total	206

DIFFICULT SOLUBILITY OF NITRATES IN SOILS.

We have taken samples of our standard soil, No. 1931, shaken them with water and determined the amount of nitrates and nitrites in the extracts. We have then taken other samples of the same soil, added known quantities of nitrates and nitrites and made determinations as before with the invariable result that it is impossible to remove all the nitrates and nitrites which are present. This point was tested somewhat with the same results during the previous year, but at that time we added very much larger amounts of nitrates. While this fact is disadvantageous to the chemist, it is of value to the farmer for his soil to have some power for preventing the leaching of nitrates.

This work involved 45 determinations in as many soils.

TIEMANN-SCHULZE METHOD.

The Tiemann-Schulze method has been looked upon as the standard method for determining nitrates, except in very small quantities, and is recognized as such in the leading text books. Using this method, we got many results so discordant that we were led to make some investigation as to its accuracy. We did this by taking distilled water which contained no nitrates and from this we could get any amount of gas we chose in the eudiometer. We got these results by taking a single sample, heating, allowing the liquid to rush back into the flask and heating again. We could also get the continued evolution of gas just as long as we heated, even without allowing the liquid to rush back. This suggested to us that the partial vacuum formed in the eudiometer was sufficient to draw air through the receiving liquid. To remedy this we used a mercury seal at the bottom of the eudiometer and found that this overcame the difficulty entirely, if a low flame was used. Previous to this we tested the gas in the eudiometer which came through the water and found it to be air.

This work involved the following determinations:

Oxygen in gas evolved	1
Carbon dioxide in gas evolved	1
Air in flask or eudiometer	51
Nitrogen as nitrate	25
Total	78

PICKEL CONDENSER FOR AMMONIA.

This condenser was devised by Dr. J. M. Pickel, of the North Carolina Department of Agriculture. The main point claimed for it is that the condensing tubes may be detached from the condensing tank, and thereby save the necessity of replacing the whole apparatus instead of a single part when only a single part is broken. The objection to this is that the ammonia and steam are condensed in the lower part of the tube and must be carried out over the bend by portions of liquid condensed later. With the tests which we made, we did not find any retention of ammonia.

This work involved 12 determinations of ammonia.

COMPARISON OF THE KELLERMAN-ROBINSON METHOD FOR ESTIMATING NITRIFICATION IN SOILS WITH THE STEVENS-WITHERS METHOD.

Kellerman and Robinson, of the United States Department of Agriculture, have proposed a method for determining the nitrifying power of soils, using a smaller amount of soil, a smaller amount of initial nitrogen and a shorter time of incubation. The result will be published showing a comparison between the two methods.

The work involved—

Nitrate determinations	46
Nitrite determinations	46
Total	92

DIPHENYLAMINE TEST FOR NITRITES AND NITRATES.

Very small quantities of nitrites and nitrates may be detected by the use of the diphenylamine reagent. The reagent and the method for making the tests are differently described by different chemists. We have made determinations as to the delicacy, following all the different methods as published. and none of them were so delicate as we wished. We have improved the reagent and modified the method so that it is possible to detect one part of nitrogen in the form of nitrates in from forty to fifty million. This is by far the most delicate test yet found. This delicacy has been tested not only by us, but by other laboratories which have followed our directions, and their results confirm our own. A paper embodying the results of our work along this line was read before the North Carolina Section of the American Chemical Society.

This work involved—

Preparation of standard solutions	167
Determination of nitrates and nitrites	925
Quantitative tests of comparative strength	82
Total	1,174

GUINEA PIG URINE.

In connection with the cottonseed meal feeding investigations we collected various samples of urine from guinea pigs which had received different feeds. These samples were collected daily and there were 168 of them. The determinations which were made were as follows:

Total quantity voided	168
Specific gravity	168
Sugar	168
Albumen	168
Urea	168
Total	840

INORGANIC ELEMENTS IN THE VISCERA OF SWINE.

From the swine that had died of cottonseed meal intoxication, we collected 15 samples of the liver, kidneys, bones and tissues. These samples were burned and qualitative inorganic analyses made of the ash. The work involved—

Systematic inorganic qualitative analyses	15
Microscopic qualitative analyses	10
Total	25

Copper and zinc were observed in small quantities. We found no inorganic substance which is classed as toxic. We omitted the examination for those elements which are known to be normal constituents of all viscera and which are not considered as toxic.

MISCELLANEOUS.

The Division has made 28 determinations in 4 samples of soil, 2 samples of corn stalks, 1 of coal, 1 of cottonseed meal, 1 for quinine as follows:

Nitrogen by Kjeldahl	2
Acidity	4
Water	14
Ash	2
Volatile matter	2
Sulphur	2
Fixed carbon	2
Total	28

Mr. Sherwood has received two flattering offers elsewhere but much to our delight decided to continue his work with the Division.

Dr. Ray has entered upon his work with enthusiasm and success. During the year he was elected Secretary of the North Carolina Section of the American Chemical Society.

During the year the chief of the Division was elected President of the Association of Official Agricultural Chemists, the oldest scientific agricultural organization in America.

We are very much pleased at the prospect of removing to more commodious quarters in the new engineering building. This will facilitate our work very materially.

With assurances of appreciation of the cordial and helpful co-operation which you have given the Division, I am,

Very respectfully,

W. A. Withers,

Chemist.

REPORT OF BIOLOGIST.

I hereby submit the report of the division under my charge for the year now closing.

Investigation of lettuce sclerotiniose has been continued, testing a theory of eradication of this disease which was formulated upon a basis of our laboratory research of earlier date. Experimental beds which suffered badly last year were almost quite exempt from disease this year following the treatment under trial. It remains to be seen whether the disease will reappear during the next or following years. Experimental spraying of the covers of the lettuce beds has proved very beneficial, extending the period of usefulness of the cloth more than a year.

The results of our research upon lettuce sclerotiniose are now nearly ready for publication. A preliminary report of these studies was made at the Boston meeting of the American Phytopathological Society.

Investigation of apple diseases has been limited to further studies of hypochnose and of a new, and what appears to be a serious canker disease, but the exact nature of which is not yet known.

Miscellaneous plant diseases which have received attention are given below:

Colletotrichum falcatum was found causing a disease of sorghum. This appears to be the first report of this disease in America.

Peanut Cercospora, also chrysanthemum rust have been noted as destructive.

Upon tobacco, thielaviose has been seen in North Carolina. This is a serious disease which originates in the seed bed.

Melon and tobacco breeding, looking toward control of the wilts of these two crops, has been continued. High resistance has been attained with melons, more than 95 per cent of which survived in thoroughly infected soil. Accompanying the resistance was a decided increase in the quality over previous years. Fourteen melons, all of which were sweet, tender, crisp, juicy and of good flavor, were selected for future breeding.

A Bulletin on cereal smuts has been prepared and is ready for press.

A Bulletin upon Apple and Pear Diseases is now in press.

A paper upon the Common Naming of Plant Diseases was prepared and presented at the last meeting of the American Phytopathological Society, held at Boston.

The plant disease survey in co-operation with the U. S. Department of Agriculture has been continued as during preceding years.

An extensive correspondence concerning plant diseases and their treatment has been conducted.

Many interesting plant diseases were collected while on an institute trip through the western part of the State.

The perfect stage of a fungus that is very widely distributed throughout the United States on Paspalum and other valuable forage grasses has been developed in culture and it proves to be a species of Claviceps. Another Claviceps heretofore unknown in perfect form has been developed from sclerotia, which are common upon Gama grass, Tripsacum.

In Soil Bacteriology work, in co-operation with the Chemistry Division, an extensive study of the inhibiting effect of organic substances upon nitrification, both in soils and in solution, has been completed.

It has been clearly demonstrated that contrary to the generally accepted opinion, nitrification is not inhibited or even retarded by organic matter; that nitrification can proceed even in pure cow manure. The inhibiting effect of organic matter, while very marked in solutions, is inappreciable in soils. The results of this investigation were presented at the Boston meeting of the American Society of Bacteriologists and appeared later in the *Centralblatt für Bakteriologie.*

An extensive bacteriological soil survey of North Carolina has been begun. Our results show that while the ammonifying power of North Carolina soils, good and poor, vary considerably, still no correlation between fertility and ammonifying power is apparent.

The soil survey will be continued during the coming year, with especial attention to nitrification.

Plat tests under carefully controlled bacteriological and chemical conditions have been conducted to determine whether ammoniacal nitrogen is as acceptable to plants as nitrate-nitrogen. This experiment will need to be continued to attain reliable results.

Some attention has been given to the associative action of various organisms upon nitrification and to the question of denitrification of nitrates in the presence of organic matter.

During the year, the Station collection of *Fungi Columbiani* has been increased to contain something over 4,400 named specimens of fungi and a number of important recent books upon plant diseases and bacteriology have been added to the library.

Respectfully submitted,

F. L. STEVENS,
Vegetable Pathologist and Bacteriologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1910.

The experimental work in feeding for egg production which was begun in 1909 has been finished this year and the results included with other matters in a bulletin which is now ready for publication. The breeding work which we have been carrying on both in regard to increased egg-production and the effects of in-breeding has been continued.

As reported last year, the use of moisture in all our incubators and their thorough disinfection at the beginning of each hatch have been adopted in our general hatching work as a result of the experiments conducted in regard to their use.

Tests of the fireless brooders in comparison with heated brooders have been made again this season. The results obtained confirm the report made last year that just as good chicks can be raised in the fireless as in the heated brooders and at a saving of at least seventy-five per cent of the cost for brooders.

FEEDING EXPERIMENTS.

At the time of last year's report the feeding experiments were not completed but a progress report was made and certain results which the work up to that time seemed to indicate were mentioned. The completion of the work made no change in these conclusions. The feeding of skim-milk had just started at the time the report was made and nothing could be said in regard to it. The work carried on during the summer months showed that for hot weather, at any rate, skim-milk is one of the most valuable feeds for egg-production that we have. It was also found that the hens on this feed not only laid more eggs at less cost than those on cottonseed meal or meat meal rations, but that they also gained more in weight and came to moulting time in better condition.

This has suggested another line of work embracing the value of the ration not only for a season's egg-production but from the standpoint of the health and breeding quality of the fowls.

For some years, the greatest drawback to extensive poultry raising has been the difficulty in raising a satisfactory percentage of the chicks hatched, and in some cases of hatching enough of the eggs set.

The heavy mortality of the chicks is in most cases attributed to white diarrhœa. This trouble is most prevalent where fowls are kept in large numbers and where they are kept more or less under artificial conditions, both as to yarding and feeding of the breeding stock and hatching and rearing of the chicks.

It has been observed in the work at this Station that hens fed on a ration rich in protein from an animal source while they lay well through the winter and do fairly well from a breeding standpoint early in the season, often show the effects of the ration later in the season and it becomes difficult to hatch good strong chicks from their eggs as the season progresses.

It has been thought that it is quite possible that the forcing rations so often used and perhaps also the restricted yard room are responsible for a large part of the losses mentioned.

In order to determine if this is so it is proposed to start experiments this year testing different rations or rather different sources of protein in the rations, making the base of all the rations the same. The experiment will also cover the yard conditions, as it is proposed to feed one lot of fowls on each ration in ordinary poultry yards set in grass and one lot on each ration in large lots where some farm crop is grown regularly.

GENERAL WORK.

There has been a steady increase in the demands made on the time of the Poultryman. The correspondence in regard to poultry matters continue to increase and there is an increasing demand for improved stock and eggs for hatching.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

REPORT OF HORTICULTURIST.

I beg to submit the following report of the work done by the Horticultural Division since June 30, 1909.

DOUBLE FLOWER OF THE DEWBERRY AND BLACKBERRY.

A large proportion of our time has been given to a study of this trouble. All of our work indicates that the trouble is due to a fungus disease. These results are very different from what we expected when the work was started. At that time it was our opinion that the trouble was due to physiological causes and not to a disease.

At present, we are trying to determine beyond a doubt whether or not the trouble is due to a disease. This is being done by a careful study of the buds; isolating the fungus found in such buds; inoculating healthy normal buds with the fungus found in practically all of these affected buds; and by thorough spraying of certain plants to prevent the entrance of fungi.

If the malady proves to be due to a fungus, it properly becomes a pathological instead of a horticultural problem.

SELF-STERILITY OF MUSCADINE GRAPES.

The work on the self-sterility of Muscadine grapes will be completed this summer and the results will be ready for publication.

SELF-STERILITY OF DEWBERRIES AND BLACKBERRIES.

The work on this problem has been continued as outlined in my last report, but on a much larger scale than heretofore. In our work during the last two years, several varieties of dewberries and some of the hybrid blackberries proved to be self-sterile. We are making a special study of the cause of self-sterility in these fruits, and some interesting results have already been obtained. For example, the pollen of the self-sterile varieties germinates readily under favorable conditions, and some of the self-sterile varieties will successfully fertilize other self-sterile varieties. This work will be continued.

PRUNING YOUNG APPLE TREES.

An experiment was begun during the past winter to determine the effect of various methods of "heading-in" young trees on the shape and frame-work of the mature tree; also its influence on the bearing age of the trees.

DROPPING OF IMMATURE FIGS.

A study has been made of the extent and cause of the dropping of immature figs. The results of this work have been published in Bulletin 208.

On September 1, 1909, Mr. L. R. Detjen became Assistant Horticulturist. He has rendered faithful and efficient service, and has proved a valuable man in carrying on the work.

Respectfully submitted, F. C. **Reimer**,
Horticulturist.

REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the Animal Husbandry Division for the fiscal year ending June 30, 1910.

The principal line of work pursued during the year was in connection with the cottonseed meal toxicity investigations, carried on in co-operation with the Chemical and Veterinary Divisions. While the work relates strictly to the hog, guinea pigs have been used largely because of their susceptibility to the toxic effects of the meal. It has been proved conclusively that commercial meal is fatal to this animal, death resulting, on an average, during the seventeenth day. During the first year of the work large hogs were used to determine the fatality of the meal under varying conditions. The premonitory symptoms could not be depended upon to indicate when the cottonseed meal should be eliminated from the ration. From all indications the only period at which the meal can be fed economically is during the later stages of growth and fattening, and then only for a limited time. Cases may be cited from the experiments where pigs weighing from twenty-five to thirty pounds were fed meal in different proportions, and in several cases the pigs receiving the least amount of meal per day died first. In three cases where pigs were fed corn meal one part and cottonseed meal one part, the animals survived for ninety-one days. On the other hand, where two and four parts of corn meal were used to one part of cottonseed meal, the total amount of mixture fed per day being approximately the same, the pigs died in seventy-eight and sixty-three days respectively. Other examples of this kind have been met with in the investigation.

The experiment planned to determine the value of cottonseed meal as a supplementary feed for horses and mules was discontinued temporarily on April 6, 1910. The results obtained so far indicate among other things that this meal may be used as a horse and mule feed to a limited extent when fed with judgment. The experiment will be resumed on July 1, 1910, and the combinations fed will consist of corn-and-cob meal, wheat bran and cottonseed meal combined with other farm-grown feeds. It has been determined that cottonseed meal may be fed most satisfactorily when given in connection with such feeds as corn-and-cob meal, wheat bran or brewers' grains.

For the first time since the writer has been connected with the Station, a car load of beef cattle was fed during the winter months. The results of the feeding were quite satisfactory, considered from every standpoint. The experiment proper was designed to determine the value of corn silage, corn stover and cottonseed hulls when fed with cottonseed meal. The results indicate that while cottonseed hulls make a very satisfactory roughage for beef cattle, corn silage and corn stover in combination and corn silage alone, gave more satisfactory results in a general way. The total gains made were greater for the lot fed on cottonseed hulls.

The swine work on the Station farm is giving very satisfactory results. A study is being made of the different grazing crops, for pork production. The crops are combined in different ways and are planted at different times so as to provide grazing for the hogs practically throughout the entire year. The combinations used as well as the time of planting are governed by the nature and character of the different crops. During the year a bulletin was prepared on the care, feeding and management of the hog in this State.

An important experiment, now in progress with swine, is planned to determine the practicability of grading up a herd of hogs from mongrel sows by the use of a pure bred sire. Complete data is being kept in this work which should, aside from the practical bearing, shed important light on the transmission of breed characteristics from both sire and dam.

Aside from the experimental work, the general management of the farm stock has required considerable time. The correspondence has increased during the year. The inquiries received were mostly concerning the adaptability of the State for the production of live stock, their feeding, general care and management.

Considerable equipment has been added during the year for carrying on the work of the Division in a more efficient manner.

Respectfully submitted,

R. S. Curtis,
Animal Husbandman.

REPORT OF DAIRY HUSBANDMAN.

The following is a report of the work of the Department of Dairy Husbandry for the fiscal year ending June 30, 1910.

The study of narrow rations for cows during the past two years has fully demonstrated that it is economical and practical to feed such rations under conditions prevailing in North Carolina. These studies have also strengthened the fact that in economical milk production the ratio of nitrogenous and non-nitrogenous nutrients in a ration must vary not only according to the flow and richness of the milk, but to some extent also, according to the relative cost of these two groups of nutrients.

In another feeding trial with cows a comparison was made of cottonseed meal and linseed meal. The results show that the two feeds are of practically equal value for milk production. The cost of the linseed meal, however, is about 20 per cent greater than that of cottonseed meal. Yet, owing to the high tonic and medical value of the former, it is urged that all dairymen feed small quantities of it, especially to cows in "off" condition and those about due to calve.

Observations have also been made as to the effect of feeding cows a ration containing one-third cottonseed meal during the month preceding calving. No ill effects of such feeding were noticeable, either on the cows or their offspring. It should be borne in mind, however, that the cows received a liberal amount of corn silage during the time these observations were made. Our feeding trials have well established the fact that cottonseed meal can be fed with much greater safety in conjunction with silage than with dry roughage.

In another investigation involving over twenty animals, observations were made on the effects of feeding a grain ration, consisting of one-third cottonseed meal, to heifers ranging from six to eighteen months of age. The daily grain allowance ranged from one and one-half pounds for the six months old heifers to two and three-quarters pounds for the eighteen months old heifers. The amount of meal fed in these trials did not appear to interfere in the least with the vigor and development of the animals. One-half of the roughage fed consisted of corn silage.

Investigations have also been made on the effects of feeding calves on old pasteurized milk and on skim-milk soured with pure cultures of lactic acid bacteria. In the main the old pasteurized skim-milk did not appear to have any appreciable effect on calves, though the same had a tendency to scours when the milk was badly curdled. Feeding skim-milk soured with lactic acid bacteria did not induce scours; on the contrary such milk had a very appreciable constipating effect. This constipating effect was so marked as to prove quite efficacious in checking calf scours. More data is needed to positively prove to what extent skim-milk soured with pure cultures of lactic acid bacteria can be used as a cure for calf scours.

Our new method of manufacturing cottage cheese, published in Bulletin 202, has been materially improved and simplified. The demand for this bulletin has been so great that the publication of another edition embodying the later work, seems justifiable.

A new method has also been worked out for the manufacture of neufchatel cheese. This method not only materially simplifies the process of making this cheese but also puts it upon a basis insuring better quality and greater uniformity than is possible with methods in vogue at the present time.

Respectfully submitted,

JOHN MICHELS,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

I beg to submit herewith a report of the work accomplished by the Entomological Division for fiscal year ending June 30, 1910.

The study of two species of melon worms, namely, *Diaphania hyalinata* and *Diaphania nitidalis,* an Adams project, was not actually commenced until about the middle of July, 1909, owing to the fact that no specimens of the worms were found previous to that date. Considerable time was spent during June and the early part of July looking, without success, for melon worms in the fields, and, when they were finally secured a month elapsed before these worms were reared to maturity and eggs secured for commencing actual breeding and life history studies.

Work with the melon worms continued during the fall of 1909 until the food plants were killed by frosts. Most of the essential points of the life history of both species were ascertained, and some parasites were reared from *D. hyalinata.* The result of this work is partially recorded under the discussion of pickle worms and melon worms in Bulletin 205, entitled "Insect Enemies of Cucumbers, Cantaloupes and Related Plants." As the work is not completed, from an investigational standpoint, it is not advisable to make it a portion of this report. Approximately three months' time was devoted to the melon worm project last fall. Furthermore, an attempt was made to keep melon worm pupæ alive during the winter, but this met with failure, as most of them were killed by parasites, while the few remaining died in the breeding cage.

Plans were made this spring to have an early field of cantaloupes with the expectation of finding melon worms early in June. However, it was June 28 before any signs of melon worms were discovered, and then only two specimens of *D. nitidalis* were discovered. The real study of the melon worms was, therefore, not commenced prior to July 1, 1910.

An outdoor breeding cage, first built in 1908, has undergone some repairs and now furnishes a very good space for the future study of melon worms, or other problems.

The cabbage webworm project was not pursued last fall, because only a very few worms were discovered, not sufficient for study. As stated in my report for 1909, this investigation may be continued when these insects appear in injurious numbers.

Without including the more common injurious insects of the year, such as codling moth, curculio, peach tree borer, San Jose scale, cabbage aphis, cabbage worms, terrapin bugs, etc., observations and records, and often photographs of the insects and their injury, were made concerning the following species:

Lesser corn stalk-borer, *Elasmopalpus lignosellus,* was discovered on September 10, 1909, working in a field of cowpeas on the Station farm; later, on the 18th, the borers were taken in corn fields, while on the 21st a few were discovered in a rank growing grass, *Paspalum sp.* on the Station farm. On September 24, these borers were taken on turnips where their work resembled that of the cabbage webworm. From specimens of the borers collected on the above dates, and later, parent moths were bred, on October 15 and November 10, and on intervening dates. On June 1, 1910, one worm was observed and during June they became rather numerous again.

Catalpa sphinx, *Ceratomia catalpa,* was found striping catalpa trees on September 10, these worms representing probably the third, and certainly the last, generation for the summer. On this date the worms were pupating in the soil under the injured trees. From some of these pupæ kept in the laboratory, an adult moth emerged September 25, and another a few days later, but most of the pupæ lived during the winter. Egg masses, larvæ, pupæ and moths were added to the collection. The worms were again present during the latter part of June, 1910.

Larger corn stalk-borer, *Diatræa saccharalis,* was unusually abundant last season, occurring in nearly all the corn fields during July, 1909. Specimens and photographs were secured. During March, 1910, these stalk borers were found in several corn fields, in the tip of the roots of the corn stubble, where they had passed the winter. On April 7, specimens were collected and the discovery made that fully 75 per cent were still in the borer stage, and the remainder in the pupæ stage. From this material, the first moth emerged on April 28, but further field observations on that date showed that many of the worms had not then pupated. These observations are entirely original for this State, and only recently discovered elsewhere.

Squash vine borer, *Melittia satyriniformis,* was rather abundant last June, July and August. Notes and photographs were secured.

Apple woolly aphis, *Schizoneura lanizera*, is everywhere abundant on apple tree roots in this section. Last July, it was found that the Station small apple orchard was being badly injured by this insect. On July 2-3 most of these trees were treated in the proper manner with kerosene emulsion at 15 per cent and 20 per cent strengths. One tree received three gallons of 20 per cent emulsion, equivalent to three quarts of actual kerosene, distributed over a circle of about four feet in diameter, and showed no injury from the treatment. The aphis were all killed where the kerosene was applied. Strong solutions of whale oil soap and also black leaf tobacco extract were tested without good results. The woolly aphis is a serious pest and one frequently overlooked by apple growers.

Striped flea-beetle, *Phylotreta vittata,* was the cause of serious damage to a field of turnips on the College farm during October. This field is situated in low ground, bordering on a creek. The beetles were unusually abundant, feeding on the foliage during the fall, but the greatest damage occurred in October when the flea-beetle larvæ attacked the young turnips, chewing off the feeding roots, and riddling the main roots. A planting about the middle of August, which was slow to start, owing to dry weather, was almost completely ruined by the flea-beetle larvæ. Fully ninety per cent of the plants died before the turnips were over one-half inch in diameter. Less severe damage occurred in other fields examined. Specimens and photographs were secured.

Cross-striped cabbage worm, *Evergestis rimosalis,* was quite abundant last summer and fall in the vicinity of Raleigh, and at other places visited by the writer. Parasites were very effective in keeping this pest in control, but notwithstanding this fact, the species was, in some instances, nearly as serious as the common cabbage worms.

Hessian fly, *Mayetiola destructor,* has escaped observation by the writer, until very recently, April 26, 1910, when it was found rather abundant in a field on the College farm. Its numbers last fall were evidently too small to cause noticeable injury. On the above date the fly was discovered in rye, a grain in which it seldom breeds freely. Should much wheat be grown here, precautions will be necessary to avoid injury from this pest.

Strawberry weevil, *Anthonomus signatus,* is not abundant in this section, but occurs in small numbers. Some injury appeared this spring in the strawberry field on the College farm.

The general insect injury for the year 1909 has not been unusual, but up to June 30, 1910, this appears to be an insect year. The common garden, field crop and fruit tree insects, have caused much damage. It is advisable to get a record of all the forms that occur, and an attempt will be made to collect and record all insects of importance during the present season.

Bulletins 205, "Insect Enemies of Cantaloupes, Cucumbers and Related Plants," and the portion of Bulletin 206, "Insects and Diseases of Apples and Pears" pertaining to insects were prepared by the Entomologist and published during the year.

Correspondence with farmers over the State has increased during the year.

Respectfully submitted,

R. I. Smith,
Entomologist.

REPORT OF VETERINARIAN.

I beg to submit the following report of the work in the Veterinary Division for the year ending June 30, 1910.

No new lines of work have been taken up and as during the year previous, we have largely devoted our attention in connection with the Animal Husbandry and Chemistry Divisions to the study of cottonseed meal and its deleterious effects when fed to swine and guinea pigs. The particular feature of the work attempted by this Division has been to determine as far as possible all the clinical symptoms and pathological lesions to be observed in animals when fed with cottonseed meal in sufficient quantities to produce illness and death. This information was desired that it might possibly throw some light upon the cause of the trouble as well as develop a more complete knowledge of the pathology of it. Observations before and after death have been made upon some twenty-five head of swine, varying in age from six months to two years. feeding upon cottonseed meal from one to eight months before dying. Similar observations were made upon some two hundred and twenty-three guinea pigs.

In addition to this line of investigation, there has been some co-operation with the State Department of Agriculture in supervising the production of a limited amount of hog cholera serum (vaccine). The results of its use in cutting short outbreaks of cholera in a number of herds were very marked.

Aside from answering an increased number of inquiries, a greater number of specimens of diseased tissues and of animal parasites were examined than heretofore.

I desire to acknowledge the creditable services of W. A. Hornaday, who assisted in laboratory and routine work.

Respectfully submitted,

G. A. Roberts,
Veterinarian

RECEIPTS AND EXPENSES.

North Carolina Agricultural Experiment Station in Account with the United States Appropriations, 1909-1910.

Dr.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1910, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	13,000.00

Cr.

	Hatch Fund.	Adams Fund.
By Salaries	$9,499.26	$7,722.40
Labor	2,851.98	1,534.75
Publications	....	....
Postage and stationery	308.29	243.81
Freight and express	176.65	133.85
Heat, light, water and power	94.11	241.97
Chemical supplies	....	432.19
Seeds, plants and sundry supplies	447.97	459.79
Fertilizers	....	547.11
Feeding stuffs	545.17	549.62
Library	58.29	119.50
Tools, implements and machinery	445.24	324.03
Furniture and fixtures	227.54	239.50
Scientific apparatus	....	111.50
Live stock	....	227.95
Traveling expenses	330.50	81.44
Contingent expenses	15.00	2.00
Buildings and land	....	28.59
Total	$15,000.00	$13,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1910; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $28,000, and the corresponding disbursements $28,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed) W. E. Daniel,
Thos. H. Blount,
O. Max Gardner,
Auditors.

(Seal.)

Attest: A. F. Bowen, *Custodian.*

SCIENTIFIC PAPERS[1]

IV—STUDIES IN SOIL BACTERIOLOGY

THE INHIBITION OF NITRIFICATION BY ORGANIC MATTER, COMPARED IN SOILS AND IN SOLUTIONS

BY

F. L. STEVENS AND W. A. WITHERS,

ASSISTED BY

P. L. GAINEY, J. K. PLUMMER AND F. W. SHERWOOD.

A long series of experiences and experiments with nitrification has convinced the writers that to ascertain facts concerning the behavior and functions of bacteria in solutions and then to deduce conclusions as to what functions these same bacteria would exercise if in soil, particularly in the presence of other species of bacteria, is to pursue a course which is extremely liable to error. We believe that we have demonstrated conclusively that such is the case.[2]

Most of the bacterio-chemical investigations of the past have been conducted, using solutions as the media for bacterial culture, and many conclusions have been deduced from such experiments regarding the physiological and chemical relations of these bacteria. These conclusions have been used extensively as though they applied to the activities of these bacteria in soils just as they do to bacteria in solutions, upon the assumption, that it is correct to translate facts ascertained by the solution method directly into terms of soils.

Perhaps the most notable illustration of this fact is the wide use that has been made of the pioneer work of Winogradsky and Omelianski[3] with regard to the inhibiting influence of the presence of organic matter upon the activity of the nitrifying organisms, who demonstrated that even very slight traces of organic matter inhibit the action of the nitrifying organisms; 0.025-0.05 per cent of glucose retarding and 0.2 per cent inhibiting entirely; 0.025 per cent of peptone retarding, 0.2 per cent inhibiting entirely; while even 0.0005 per cent of ammonia retarded the action of the nitrate organism and 0.015 per cent inhibited its action entirely. This work, as is well known, was done with pure cultures employing solutions as the media. Nevertheless, the conclusions deduced therefrom have been extended not only to soils, where many species of bacteria are present, but to agricultural practice; without any serious attempt to ascertain whether the conclusions are really applicable at all to soils, in which the bacteria under consideration normally live.

---

[1] Published originally in Cent. f. Bak. II. Abt. Bd. 27, 169.

[2] Studies in Soil Bacteriology: I. Nitrification in Soils and Solutions (Centbl. Bakt., [etc.] Abt. II, Bd. 23, 1909, p. 355, and 31st Annual Report N. C. Station [1907-8], pp. 40-63). II. Ammonification in Soils and Solutions: (Ibidem Bd. 23, p. 776). III. Concerning Methods for Determination of Nitrifying and Ammonifying Powers: (Ibidem Bd. 25; [1909, p. 61] and 32d Ann. Rept. N. C. Station [1908-9] pp 129-144.

[3] Winogradsky, S. Ann. Inst. Pasteur T. 4, (1890) p. 213. Winogradsky und Omeliansky, Ueber den 'Einfluss der organischen Substanzen auf die Arbeit der nitrifizierenden Mikrobien. Centbl. Bakt. (etc.) Abt. II, Bd. 5 (1899), p. 329.

A question of fundamental importance thus comes to view, viz: *"Is the inhibiting influence of organic matter and of other substances the same in soils as it is in solutions?"*

It is the purpose of this paper to present the results of certain experiments bearing upon this question.

All experiments, unless otherwise stated, were made in a manner similar to those cited in our earlier articles.[1]

Experiment 249, Feb. 18, 1909.—To determine the inhibiting amount of peptone in soil and in solution.

400 grams of sterile soil No. 1931 in each of six Erlenmeyer flasks were used as the medium; 240 mgs. of nitrogen as sterile ammonium sulphate were added. Each flask was inoculated with 80 c.c. of suspension of Georgia soil No. 1, and to each flask was added peptone to give the amounts indicated in table 1.

Thus each flask of soil carried the same amount of soil and of water; the only variant was the peptone. Account was taken of the water already present in the soil so that the per cent indicated is the per cent of peptone actually present in the total water in the flask when the experiment was set up. Six other flasks contained Omeliansky's solution as the medium. These received the peptone and were inoculated as were the flasks containing soil, with the exception that only 10 c.c. of inoculum were used.

Two such series of flasks were set up, one analyzed at the end of four weeks, the other at the end of sixteen weeks. The results appear in table 1.

Although nitrification was quite vigorous in the solution devoid of organic matter, both at the end of four weeks and at four months, no nitrification sufficient to show by diphenylamine occurred during either of these periods in any of the solutions containing organic matter as peptone. Notwithstanding the complete inhibiting effect of the peptone even in very small amounts in the solutions no such complete inhibition is shown with soil as the medium. Though there is a slight decrease in total nitrification with increase in peptone this is not marked until 2.5 per cent of peptone is reached, and inhibition is not complete until the amount becomes 5 per cent. If we regard the results of the longer incubation period the presence of even 5 per cent of peptone seems to have no retarding effect.

The objection may possibly be raised that during the course of the experiment the organic matter was destroyed by putrefactive or ammonifying bacteria introduced by the inoculum. Such objection, is however, not tenable since all solution cultures received the same kind of inoculum as did the soil cultures, and the destruction of organic matter proceeds nearly as rapidly in the solutions as in the soils.[2]

It may be remarked here, in passing, that this experiment as well as scores of others which we have already reported gives ample evidence that sterilization of soil in the autoclave as was here done does not destroy the ability of the soil to support nitrification.

---

[1] Stevens and Withers.

[2] Cf. also experiment 348.

This remark is called for by the recent statement of Miller and Hutchinson[1] that in their experience some soils were not able to produce nitrate after partial sterilization even though subsequently inoculated. It is to be noted, however, that they employed only *partial sterilization* and the effects they noted may be attributed to denitrification. In any event sterilization does not in general incapacitate a soil from nitrifying if subsequently supplied with nitrifying organisms.

TABLE I.—Inhibition of nitrification by peptone in soil and in solution.

Flask No.	Medium.	Percent of Peptone.	Days Incubated.	Percent of original added nitrogen recovered as:		
				Nitrites.	Nitrates.	Nitrites and Nitrates.
1	Soil.	0.00	28	7.50	58.87	66.37
2	“	0.80	28	6.00	53.19	59.19
3	“	1.00	28	6.00	50.37	56.37
4	“	1.25	28	5.00	31.33	36.33
5	“	2.50	28	3.00	12.66	15.16
6	“	5.00	28	0.00	0.00	0.00
7	Omeliansky's solution.	0.00	28	2.33	19.65	21.98
8	“	0.80	28	0.00	0.00	0.00[a]
9	“	1.00	28	0.00	0.00	0.00[a]
10	“	1.25	28	0.00	0.00	0.00[a]
11	“	2.50	28	0.00	0.00	0.00[a]
12	“	5.00	28	0.00	0.00	0.00[a]
13	Soil.	0.00	112	0.00	83.31	83.31
14	“	0.80	112	0.00	103.14	103.14
15	“	1.00	112	0.00	113.38	113.38
16	“	1.25	112	0.00	125.36	125.36
17	“	2.50	112	0.00	174.85	174.85
18	“	5.00	112	0.00	204.07	204.07
19	Omeliansky's solution.	0.00	112	tr.	91.15	91.15
20	“	0.80	112	0.00	0.00	0.00[a]
21	“	1.00	112	0.00	0.00	0.00[a]
22	“	1.25	112	0.00	0.00	0.00[a]
23	“	2.50	112	0.00	0.00	0.00[a]
24	“	5.00	112	0.00	0.00	0.00[a]

[a] Nitrites and nitrates were tested for with diphenylamine solution. In case there was a coloration after one or two minutes the amount of nitrites and nitrates was determined by the Tiemann-Schulze method. If only a faint coloration appeared, which disappeared upon shaking, a trace was reported, and if no coloration at all appeared, the amount of nitrites and nitrates was recorded as zero. The test was made as follows: (Treadwell, Anal. Chem. translated by *Hall*, Vol. 1, 1906, p. 340.)

"The reagent is prepared by dissolving 0.5 grams of diphenylamine in 100 cc. of pure concentrated sulphuric acid and adding 20 cc. of water. A few cubic centimeters of the diphenylamine solution are placed in a test tube and carefully covered with the solution to be tested for nitric acid. If the latter is present, there is formed at the zone of contact between the two liquids a ring of a beautiful blue color."

Treadwell states that "if one cc. of an acid (concentrated sulphuric S. and W.) which contains only one twentieth milligram of nitrogen in a liter is used, the reaction will cause a noticeable coloration."

This test is less delicate in water solutions than in concentrated sulphuric acid. Wherever the amount of nitrites or nitrates is recorded in this article as zero small amounts may have been present and escaped detection.

Experiment No. 91.—To determine the amount of cottonseed meal necessary to inhibit nitrification in soil.

Six Erlenmeyer flasks containing 400 grams of sterile soil No. 1867 were prepared. Each flask received 240 mgs. of nitrogen as sterile ammonium sulphate and was inoculated with 1 c.c. of pure culture of nitrite and nitrate-forming bacteria. Cottonseed meal, carrying nitrogen varying in amount from 0 grams to 0.5 grams, was added. All were analyzed at the end of four weeks. The results are given in Table II.

---

[1] Jour. Agr. Sc. 3, (1909)

TABLE II.—Amount of cottonseed meal inhibiting nitrification in soil.

Flask No.	Grams of nitrogen as C. S. M.	Percentage of original nitrogen recovered as:	
		Nitrites.	Nitrites and Nitrates.
1	0.0	0.0	63.5
2	0.1	tr.	60.5
3	0.2	0.0	27.1
4	0.3	0.0	53.2
5	0.4	7.5	22.3
6	0.5	7.5	29.1

It is seen that cottonseed meal in these amounts does not inhibit nitrification in soil.

Experiment No. 109.—To determine the amount of cottonseed meal necessary to inhibit nitrification in soil.

This experiment was set up similar to experiment No. 91, employing varying amounts of cottonseed meal, supplying nitrogen varying from 0 to 2 grams. The results appear in Table III.

TABLE III.—Amount of cottonseed meal necessary to inhibit nitrification in soil.

Flask No.	Grams of nitrogen as C. S. M.	Percentage of initial nitrogen recovered as:		
		Nitrites.	Nitrates.	Nitrites and Nitrates.
1	0.0	2.54	37.58	40.12
2	0.0	2.54	40.09	42.63
3	0.5	8.46	60.76	69.22
4	0.5	10.88	60.76	71.64
5	2.0	0.00	0.00	0.00[1]
6	2.0	0.00	0.00	0.00[1]

[1] No reaction with diphenylamine.

It is seen here that while 0.5 grams is not inhibitory 2.0 grams are entirely so.

Experiment No. 250.—To compare inhibiting action of cottonseed meal upon nitrification in soil and in solution.

This experiment was set up similar to experiment No. 249 with the exception that cottonseed meal was used instead of peptone. The results are given in Table IV.

Table IV.—Inhibition of nitrification by cottonseed meal in soil and in solution.

Flask No.	Medium.	Grams of nitrogen as C. S. M.	Days incubated.	Percentage of initial nitrogen recovered as:		
				Nitrites.	Nitrates.	Nitrites and Nitrates.
1	Soil.	0.0	28	Lost	Lost	Lost
2	"	0.1	28	7.50	61.64	68.90
3	"	0.2	28	10.00	52.64	62.64
4	"	0.3	28	7.50	53.89	61.39
5	"	0.4	28	6.00	45.36	51.36
6	"	0.5	28	5.00	23.21	38.21
7	Omeliansky's solution	0.0	28	1.76	11.81	13.57
8	"	0.1	28	0.00	0.00	0.00[1]
9	"	0.2	28	0.00	0.00	0.00
10	"	0.3	28	0.00	0.00	0.00[1]
11	"	0.4	28	0.00	0.00	0.00[1]
12	"	0.5	28	0.00	0.00	0.00[1]
13	Soil.	0.0	112	0.00	90.20	90.20
14	"	0.1	112	0.00	100.90	100.90
15	"	0.2	112	0.00	103.20	103.20
16	"	0.3	112	0.00	103.20	103.20
17	"	0.4	112	0.00	100.90	100.90
18	"	0.5	112	0.00	96.47	96.47
19	Omeliansky's solution	0.0	112	tr.	87.91	87.91
20	"	0.1	112	0.00	0.00	0.00[1]
21	"	0.2	112	0.00	0.00	0.00[1]
22	"	0.3	112	0.00	0.00	0.00[1]
23	"	0.4	112	0.00	0.00	0.00[1]
24	"	0.5	112	0.00	0.00	0.00[1]

[1] No reaction with diphenylamine.

It again appears that nitrification proceeded well in the solution bearing no cottonseed meal; but that cottonseed meal when present in the solution inhibited nitrification. In soils, however, there was but slight retarding influence due to the presence of the cottonseed meal and complete inhibition in no case.

The results at the period of four months indicate that some of the cottonseed-meal-nitrogen was then nitrified. Thus some of the organic matter was removed from the medium. Such removal is, however, not sufficient to explain this difference in the inhibiting effect of organic matter in soils and in solutions.

That the removal of the organic matter is not necessary before nitrification can proceed is directly shown by the following experiments:

Experiment No. 251, April 12, 1909.—To determine whether in soils rich in organic matter the destruction of organic matter by putrefaction or ammonification is necessary before nitrification can begin.

Eighteen flasks, each containing 400 grams of sterilized soil No. 1931, plus 240 mgs. of nitrogen as sterile ammonium sulphate were inoculated with a vigorously nitrifying soil (Georgia soil No. 1). Fresh cow manure in varying amounts was mixed with the soil in the flasks as is indicated in table 5, giving a range in amount from 200 mgs. to 32,000 mgs., or in terms of field practice from 1 ton to 160 tons per acre.[1] The manure as weighed into the first sixteen flasks was fresh, undried and contained much water, approximately 560 grams per 100 grams of dry matter. Two flasks, Nos. 17 and 18, received no manure. Nos. 19

---

[1] For purposes of this calculation the acre is regarded as weighing 4,000,000 lbs.

and 20 contained pure, partially dried, cow manure and no soil. The manure here used had been dried for several days in a steam heated closet and contained 264 grams of water for each 100 grams of dry matter. Nos. 21 and 22 were duplicates of the two latter but were left without inoculation to serve as controls. The cow manure in all cases was just as dropped by the cow without any addition of foreign material. The whole series of twenty-two flasks was set up in quintuplicate, making a total of one hundred and ten flasks. The five series were analyzed as follows: I at time of setting up, II at two weeks, III at four weeks, IV at eight weeks, V at twelve weeks.

There was no reaction with diphenylamine in series I, II and III, representing 0, 14 and 28 days, except that in some cases, bare traces of nitrates or nitrites were indicated. There was no reaction for nitrites by the Griess method in any case.

All flasks were set up in duplicate and the duplicates agreed well, only averages are given.

The results are presented in table V.

In the results of analyses of the first two series, neither the soil nor the manure possessed either nitrites or nitrates in appreciable amount, nor did any appear in any flask until the third analysis period, which was at the end of four weeks. Then four pairs of flasks showed nitrites and nitrates but in amounts too small to measure by the Tiemann-Schulze method. At the end of eight weeks there was considerable nitrification in all of the flasks except the two pairs which were not inoculated.

TABLE V.—Showing nitrification in the presence of large amounts of organic matter.

Flask No.	Medium.	Amount of cow manure added, Mgs.	In tons per acre	Percentage of initial nitrogen recovered as:						
				Ammonia.					Nitrates.	
				Series I 0 days.	Series II 14 days.	Series III 28 days.	Series IV 56 days.	Series V 84 days.	Series IV 56 days.	Series V 84 days.
1-2	Soils 240 mgs. N as Ams	200	1	55.42	77.36	76.92	71.62	65.37	9.55	15.51
3-4	"	1,000	5	61.97	64.77	62.95	67.05	60.92	11.75	19.11
5-6	"	2,000	10	65.12	74.57	78.07	63.86	68.61	12.22	0.00[1]
7-8	"	4,000	20	65.82	75.97	69.67	67.33	69.67	12.69	25.37
9-10	"	6,000	30	69.62	74.57	74.47	70.83	61.27	13.46	27.88
11-12	"	8,000	40	67.22	76.32	77.09	72.57	Lost	13.46	Lost
13-14	"	16,000	80	71.07	71.77	69.86	53.69	63.62	12.52	33.04
15-16	"	32,000	160	72.47	72.47	61.10	50.16	58.46	12.59	51.37
17-18	"	0	0	31.86	18.20	68.31	67.05	59.17	0.00[1]	29.75
19-20	No soil. 240 Mgs. N as Ams	75,000		65.47	55.32	52.58	65.12	65.12	18.17	135.30
21-22	"	75,000		58.11	58.82	57.42	59.87	68.62	0.00[1]	17.54

[1] No reaction with diphenylamine.

It is noted further that nitrification was not least where organic matter was most, nor most where organic matter was least; but that exactly the reverse was true. *Nitrification was most where organic matter was most. It was highest in the pure cow manure in flasks Nos. 19 and 20.* Throughout the intermediate flasks of the series there was but little variation, making it apparent that the organic matter of this kind is practically without influence upon nitrification in soil and in the presence of bacteria of many kinds, except as it is a cource of ammonia. When organic matter is present in large amounts as in flasks Nos. 19 and 20, the extra ammonia afforded to the bacteria by the ammonification of the cow manure permitted some increase in nitrification.

The result of the fifth series, analyzed at twelve weeks, fully confirm the conclusions from the previous series as to the ability of nitrifying organisms to nitrify in the presence of cow manure, flasks 18 and 19 giving a higher nitrification than we have met with in any analysis of the past four years' work. The third, eighth and tenth pairs of flasks, containing respectively 2,000 mgs., 32,000 mgs., 175,000 mgs. of cow manure, present inexplicable anomalies, possibly due to interference of fungi or to accidental inoculation with nitrifiers during the long course of the experiment; but these in no wise interfere with the general conclusions as to the possibility of nitrification in the presence of organic matter.

The changes in ammonia throughout the experiment were surprisingly slight and such variations as are found might well result from differences in the material placed in the flasks rather than from changes induced by bacteria. The process of nitrification is shown to have kept pace with the ammonification through the eighth week, nitrifying the ammonia as fast as it was made.

While no direct analyses were made of the fourth series for organic matter or organic nitrogen, the absence of any increase in ammonia gives strong presumptive evidence that the organic matter as such still existed in the soil at the eighth week, prior to which time vigorous nitrification was well under way.

The presence of much organic matter in the medium simultaneously with the procedure of nitrification is particularly evident in flasks Nos. 19 and 20, which contained no soil but only cow manure plus ammonium sulphate, as the medium. That the organic matter of this pure cow manure could have been completely destroyed by any process prior to the beginning of nitrification and yet have shown no large increase in ammonia is inconceivable.

This nitrification of the pure cow manure was unexpected, yet the case is not without parallel since Livingston[1] mentions nitrification of stable manure and Holdefleiss and others, as cited by Löhnis[2] report such nitrification.

As the amounts of organic matter were not determined in the experiment just referred to, a similar additional experiment was made, as follows:

Experiment 348, October 13, 1909.—To determine whether the organic matter in the soil must first ammonify to enable nitrification, also the effect upon nitrification of varying amounts of cow manure, representing a wide range of field conditions.

Twelve flasks, each containing 400 grams of sterilized soil No. 1931. and 240 mgs. nitrogen as sterile ammonium sulphate, were inoculated with a vigorously nitrifying soil (Georgia soil No. 1.) Fresh cow manure was mixed with the soil in the flasks in amounts of 200, 8,000 and 32,000 milligrams to 400 grams of soil, or in terms of field practice, 1 ton, 40 tons and 160 tons per acre,[3] respectively.

---

[1] U. S. Dept. agr. Bur. Soils, Bulletin 36, page 47.
[2] Löhnis, l. c.

The manure as weighed into the first 6 flasks was fresh, undried and contained much water, approximately 560 grams per 100 grams of dry matter. Two flasks, Nos. 7 and 8, received no manure, Nos. 9, 10, 11 and 12 contained partially dried cow manure and no soil. The manure here used had been dried for several days in a steam heated closet and contained 264 grams of water for each 100 grams of dry matter. Nos. 9 and 10 were inoculated like the previous samples, but 11 and 12 were left without inoculation to serve as controls. The cow manure in all cases was just as dropped by the cows without any additional foreign material. The whole series of 12 flasks was set up in triplicate, making a total of 36 flasks. The three series were analyzed as follows: Series I at time of setting up; Series II at four weeks; and Series III at eight weeks. In addition to the usual analyses, determinations were made of volatile matter, humus, and total nitrogen. The methods of the Association of Official Agricultural Chemists were followed.[4]

The results are given in Table VI.

TABLE VI.—Showing nitrification in the presence of large amounts of organic matter.
Series I.—No Weeks.[1]

Flask No.	Medium.	Cow Manure added Mgs.	Tons per acre	Volatile matter[2] Percent.	Humus[2] Percent.	Total nitrogen[2] Percent.	Percent of initial nitrogen recovered as ammonia.
1	400 grms. soil and 240 mgs. N as Ams.	200	1	4.36	....	0.091	61.62
2	"	200	1	4.73	4.40	0.098	60.92
Aver.		....	....	4.54	....	0.095	61.27
3	"	8,000	40	4.76	4.18	0.086	62.32
4	"	8,000	40	4.04	3.20	0.112	61.97
Aver.		....	....	4.40	3.69	0.099	62.15
5	"	32,000	160	5.80	....	0.165	64.42
6	"	32,000	160	5.38	4.56	0.126	65.82
Aver.		....	....	5.59	....	0.146	65.12
7	"	0	0	4.46	2.44	0.088	60.92
8	"	0	0	4.26	2.26	Lost	60.92
Aver.		....	....	4.36	2.35	0.088	60.92
9	No soil. 240 mgs. N as Ams	75,000	....	77.74	21.16	2.746	Lost
10	"	75,000	....	77.41	18.32	2.369	108.50
Aver.		....	....	77.58	19.74	2.558	108.50
11	"	75,000	....	88.70	25.44	Lost	Lost
12	"	75,000	....	89.53	63.36	2.398	154.04
Aver.		....	....	88.62	44.40	2.398	154.04

[1] Series I at 0 weeks did not give any reaction with diphenylamine (Treadwell's method).
[2] Based upon dry substance.

---

[3] For purposes of this calculation the acre is regarded as weighing 4,000,000 lbs.
[4] U. S. Dept. Agr., Bur. Chem., Bul. 107 revised (1908), pp. 7, 14 and 19.

Series II—Four Weeks.

Flask No.	Medium.	Cow manure added, Mgs.	Tons per acre.	Volatile matter,[1] Percent.	Humus,[1] Percent.	Total nitrogen,[1] Percent.	Percent of initial added nitrogen recovered as:		
							Ammo.	Nitrites.	Nitrates.
1	400 grms. soil and 240 mgs. N as Ams.	200	1	4.67	0.78	0.098	9.10	0.70	69.45
2	"	200	1	2.48	0.50	0.154	13.30	Lost	77.67
Aver.				3.58	0.64	0.126	11.20	0.70	73.56
3	"	8,000	40	4.56	0.66	0.133	10.50	Lost	70.15
4	"	8,000	40	4.45	1.14	0.140	12.25	Lost	58.25
Aver.				4.51	0.90	0.137	11.38	Lost	64.20
5	"	32,000	160	4.95	1.22	0.351	3.50	0.40	54.41
6	"	32,000	160	5.06	1.66	0.126	3.15	Lost	43.22
Aver.				5.01	1.44	0.239	3.33	0.40	48.82
7	"	0	0	4.40	1.26	0.169	14.70	0.00	69.53
8	"			4.44	1.38	0.183	24.86	0.55	78.39
Aver.				4.42	1.32	0.176	19.78	0.28	73.96
9	No soil 240 mgs N as Ams.	75,000					37.46		
10	"	75,000					32.21		
Aver.							34.84		
11	"	75,000					88.92		
12	"	75,000					86.82		
Aver.							87.87		

Series III—8 Weeks.

Flask No.	Medium.	Cow manure added, Mgs.	Tons per acre.	Volatile matter,[1] Percent.	Humus,[1] Percent.	Total nitrogen,[1] Percent.	Percent of initial added nitrogen recovered as:		
							Ammonia.	Nitrites.	Nitrates.
1	400 grms. soil and 240 mgs. N. as Ams.	200	1	4.12	0.50	0.12	2.8	0.2	83.1
2	"	200	1	4.35	0.58	0.13	2.1	0.2	79.4
Aver.				4.23	0.54	0.13	2.5	0.2	81.3
3	"	8,000	40	4.41	0.60	0.05	1.4[2]	1.1	81.0
4	"	8,000	40	4.62	0.70	Lost	13.3[3]	0.8	80.6
Aver.				4.52	0.65	0.05	7.4	0.9	80.5
5	"	32,000	160	4.50	0.58	0.09	8.4[4]	1.0[6]	56.0
6	"	32,000	160	4.60	0.58	0.13	0.0[5]	0.3[7]	55.5
Aver.				4.55	0.58	0.11	4.2	0.7	55.8
7	"	0	0	4.50	0.48	0.10	0.7	0.2	93.5
8	"	0	0	4.60	1.08	0.14	0.0	0.2	96.7
Aver.				4.55	0.78	0.12	0.4	0.2	95.1
9	No soil 240 mgs N as Ams.	75,000	......	79.10	6.96	3.20	7.7	0.0	64.8[8]
10	"	75,000	......	72.30	5.84	3.45	8.1	0.0	18.5[9]
Aver.				75.70	6.40	3.33	7.9	0.0	41.7
11	"	75,000	......	86.90	6.32	2.87	55.3	0.0	0.0
12	"	75,000	......	85.90	6.32	2.85	53.2	0.0	0.0
Aver.				86.40	6.32	2.86	54.3	0.0	0.0

[1] Based upon dry substance.
[2] Duplicate 1.4.
[3] Duplicate 14.0.
[4] Duplicate 9.1.
[5] Duplicate 0.7.
[6] Duplicate 1.0.
[7] Duplicate 0.3.
[8] Duplicate 60.1.
[9] Duplicate 19.4.

From the foregoing tables we have the following averages:

Flask No.	At end of weeks—	Volatile matter, Percent.	Humus, Percent.	Percent of initial added nitrogen recovered as:	
				Nitrites.	Nitrates.
1-2	4	3.58	0.64	0.70	73.56
3-4	4	4.51	0.90	----------------	64.20
5-6	4	5.01	1.44	0.40	48.82
7-8	4	4.42	1.32	0.28	73.96
1-2	8	4.23	0.54	0.20	81.30
3-4	8	4.52	0.65	0.90	80.80
5-6	8	4.60	0.58	0.70	55.80
7-8	8	4.60	0.78	0.20	95.10
9-10	8	75.7	6.40	0.00	41.70
11-12	8	86.4	6.32	0.00	0.00

It will be noted from the above table that at both 4 and 8 weeks nitrification occurred in all samples of soil, which contained an admixture of cow manure whether in small or large amounts and that at the end of the periods organic matter was still present as shown by the volatile matter and the humus. It will be noted, however, that although there was good nitrification this was larger when the amounts of added cow manure were smaller, and this is true for both the four and eight weeks periods.

That nitrification can proceed in the presence of organic matter is shown in a most forcible way from the fact that at eight weeks 41.7 per cent of the nitrogen added to cow manure as ammonium sulphate was changed to nitrates (flasks 9 and 10) and that there was present at the end of the period 75.7 per cent of volatile matter of which 6.40 per cent was humus. A control sample which stood for the same period without inoculation showed no nitrates nor nitrites with diphenylamine.

The results reported above clearly justify two conclusions.

1. The inhibiting influence of organic matter, (Peptone or cottonseed meal) is much greater in solutions, such as Omeliansky's than it is in soil water.
2. Nitrification can proceed vigorously in the soil in the presence of large quantities of such organic matter, as that of peptone, cottonseed meal, or cow manure.

GENERAL DISCUSSION.

PREVAILING VIEWS REGARDING NITRIFICATION

Following the utterance of Winogradsky's conclusions,[1] came their adoption by numerous text books upon bacteriology.

---

[1] They may be expressed in their latest wording, in their application to natural conditions as follows, quoted fromLafar's Handb. de Techn. Mykologie Bd. III, p. 178.

"Auf die Frage, warum diese drei Prozesse, Ammoniakdildung, Nitritation and Nitratation, bei gemeinsamer Anwesenheit ihrer zugehörigen Erreger im Substrate nicht Hand in Handgehen, sondern immer in derselben Reihenfolge nacheinander sich abspielen, gibt uns die Physiologie der Nitrifikationsbakterien eine bestimmte Antwort. Es ist einerseits die Abneigung des Nitritbildners gegen organische Stoffe, andererseits die des Nitratbildners gegen Ammoniak, welche hier regulierend eingreifen. Solange die organischen Stoffe nicht bis auf ein ertragliches Geringstmass hinabgedruckt und in einfachere Verbindungen gespalten sind, solange kann der Nitritbildner, trotz Reichtum an Ammon, nicht aufkommen. Ist nur der Nitritbildner imstande, die Ammoniak-oxydation zu beginnin, so muss der Nitratbildner, trotz Vorhandene sein von Nitrit noch untätig bleiben, weil er durch das vorhandene Ammon noch gelähmt wird. Erst wenn das Ammoniak fertig nitritiert ist kann nun die dritte Stufe des natürlichen Prozesses, die Nitratation sich geltend machen."

Thus Löhnis[1] cites Migula,[2] Lemmerman, Behrens[3] Günther,[4] Schmidt and Weis,[5] Fischer[6] and others in such terms as to indicate their acceptance of Winogradsky's views concerning the restricting influence of organic matter or ammonia upon the process of nitrification.

In American and English works we find the same views reflected in the following passages:

"The presence of very small amounts of easily oxidizable organic compounds is detrimental to the growth and activity of both types of nitrifying organisms, the nitrite-forming bacteria being more sensitive in this respect than the nitrate-forming species. On this account the nitrification process does not begin until all the organic material has been fermented by other species of bacteria."[7]

"The presence of a small amount of organic matter in the culture media is directly injurious to these (nitrifying) organisms * * *

"A solution * * * which has no trace of organic matter, furnishes them with the proper conditions for growth.

"It appears that the presence of organic matter in the solutions even in very small quantities is directly injurious * * * if a small quantity of organic matter is added their growth is stopped. So sensitive are they to organic matter that these compounds act exactly like antiseptics. When present in very small quantities they are able to stop the growth of the bacteria, acting as powerfully in this respect as antiseptic poisons act upon ordinary bacteria. * * *

"Further it is found that the more highly organized the compound the more decided is its checking action upon the nitro-bacteria, * * * here is a group of organisms that not only does not need, but can not grow in the presence of organic matter.

"The building of nitrates will not take place in the soil so long as there is any considerable amount of organic material, or any considerable amount of free ammonia present. If there is much organic material rapidly decomposing so as to produce ammonia, this will completely check the formation of nitrates, for these nitrifying bacteria will not grow in the presence of either organic material or ammonia. It is not until after decomposition has been completed and practically all the organic compounds used up that the nitrifying germs can begin to act."[8]

"The nitrifying organism will not grow in a medium containing any considerable amount of soluble organic matter.

"Where sewage is applied to land nitrification can not, therefore, begin until after the ordinary putrefying and ammonifying bacteria have decomposed much of the organic matter and rendered the soil water a fit pabulum for the development of nitrifying ferments.

---

[1] Löhnis, F., Ueber Nitrifikation und Denitrifikation in der Ackererde. Centbl. Bakt. [etc.] Abt. II. Vol. 13, p. 706.

[2] Migula, in De Barys Vorlesungen. 3. Aufl. 1900, p. 105, and Migula, Die Bakterien, 2, Aufl., 1903, p. 161 Lemmerman, Behrens 5.

[3] Behrens, Neuere Fortschritte in Wirtschaftsbetrieb und Bodenkultur. Vorträge. 1911. p. 127. und Mitt. Deuts. Landw. Gessell. 1904, p. 184.

[4] Gunther, Einf. in d. Studium d. Bakteriologie. 5, Aufl. p. 2. Abdruck. 1902, p. 61.

[5] Schmidt und Weis, Die Bakterien, 1902, p. 322.

[6] Fischer, A., Vorlesungen. 2. 1903, Aufl., p. 189,

[7] Percival, John, Agricul. Botany, 1900, p. 765.

[8] Conn, H. W., Agricultural Bacteriology, 1901, pp. 95, 99, 100, 103.

"For this reason sewage when applied to land should be used cautiously and not too frequently, otherwise the soil will become so rich in soluble organic matter as to hinder nitrification.

"Thus a soil too rich in humus is an unfavorable nitrifying ground * * * Wiley mentions a soil from Florida containing over 80 per cent of organic matter * * * which was entirely free from nitrifying ferments."[1]

"The principal organic food of the nitrifying organism is the organic matter of the soil and it is only when organic matter is incorporated with the soil that it can serve as food for nitrifying organisms.

"In the presence of a large amount of organic matter, as in a manure pile, nitrification does not take place. It occurs only when organic matter is largely diluted with soil."[2]

"The nitrifying organism * * * is directly inhibted by the presence of organic matter.

"It is probable that carbon dioxide is the only available source of carbon, since organic substances, like glucose and peptone, not only do not favor growth, but exercise an inhibitory influence upon the nitrite-forming organism, and may even check it altogether * * * In the presence of nitrogenous substances like urea, asparagin and egg-albumen, Nitrosomonas remains impotent, and no trace of either nitrite or ammonia formation is found after the lapse of months.

"Given ammonia as a starting point, nitrite formation can occur, provided too much organic matter be not present."[3]

The acceptance of these views by recent research workers in this field is fairly shown by the following quotations from the literature:

"Increasing the quantity of organic nitrogen from 1 to 3 gr. per kg. of soil was clearly unfavorable to nitrification. Not only the relative proportions, but also the absolute quantities of nitric nitrogen decreased as the amount of organic nitrogen increased.

"If it is desired in the preparation of composts to transform nitrogenous organic matter into nitrate, the mixture should not contain over 1 gr. of nitrogen per kg."[4]

"In cultivating both of the organisms (nitrite and nitrate) in solutions and in jelly I can only confirm Winogradsky's methods, which I have followed rigidly with the best results. The presence of inorganic substances only is the most favorable condition for development."[5]

"Leme, Pichard, and others have shown that an excess of organic matter tends to check or prevent nitrification. Davy observes that the reduction in nitrification is especially marked when the excess of organic nitrogen is of animal origin."[6]

---

[1] Chester, Frederick D., Bacteria of the Soil in their relation to Agriculture, Penn., Bul. 98, 1902, p. 44.

[2] Snyder, Harry, Soils and Fertilizers, 1908, p, 137.

[3] Jordan, Edwin O., a Text Book of general Bacteriology, 1908, pp. 493, 495, 497.

[4] Pichard, P., effects of different proportions of clay and of organic nitrogen on the fixation of atmospheric nitrogen, the conservation of nitrogen and nitrification, Compt. Rend. Acad. Sci. [Paris] T. 114, 1892, p. 81-84. E. S. S., Vol. III, p. 639.

[5] Schultz-Schultzenstein, Technol, Quart., Vol XVII, 1904, No. 2. The Nitrifying Organisms in Sewage Filters (Translated by A. E. Kimberly).

[6] Gage, Stephen D. M., the Bacteriolysis of Peptones and Nitrates, Technol. Quart., Vol. 18, 1905, p. 14.

The apparent irreconcilability existing between the conclusions of Winogradsky and the obvious phenomena of nature caused some to hesitate in their unqualified acceptance. Thus we find Chester after quoting Winogradsky's views and subscribing to them as quoted above, making the following statement:

"In ordinary arable land, however, the quantity of organic matter, or humus, never reaches a height sufficient to interfere with the process of nitrification. * * *."

Other recent writers upon this subject have been significantly silent regarding the inhibitory influence of organic substance upon nitrification without, however, adducing any evidence bearing upon the question.

RECENT RESEARCH.

Certain recent researches having a more or less direct bearing upon the question of the validity of applying Winogradsky's conclusions to field conditions may now be mentioned.

Withers and Fraps[1] determined the nitrifying power and humus content of fifteen typical North Carolina soils and found the highest nitrifying power in the soil containing the highest per cent of humus. The humus in this case was 2.66 per cent and 33.1 per cent of the initial added nitrogen (.3 grs. in 500 grs. soil) was nitrified equivalent to 198 parts N. as nitrates in one million parts of soil. The authors state that "most of the soils high in humus are high in nitrifying power." In the same publication they report experiments showing that the addition of 3.22 per cent of dried barnyard manure to the soil in three cases gave less nitrification, after four or five weeks, and in the fourth case only very little more nitrification than the soil itself.

Löhnis,[2] employing soil extract and inoculating with crude, live soil, showed that the organic matter in such solutions does not under these conditions inhibit nitrification and, indeed, that nitrification could still proceed when there was organic matter enough present to enable denitrifying bacteria to grow.

Wimmer[3] has shown that nitrification by pure cultures is more rapid in solutions absorbed by sand to moderate condition of moisture (krümelige) than in ordinary solutions, also that the inhibiting influence of peptone, when in solutions absorbed by sand, is much less than when the solutions are not so absorbed; 0.2 per cent of peptone was inhibitive in solutions, 0.4 per cent was necessary when in the presence of the sand.

Gutzeit[4] found the organic matter of soil extract not inhibitative of nitrification.

Buhlert and Fickendey[5] found nitrification in abundance in soil extract and that soils of high humus content are more vigorous nitrifiers than those poorer in humus.

---

[1] Rep. N. C. Stat., 1902-03, pp. 57-63

[2] Cent. f. Bakt. [etc.] Abt. II, Bd. 12, [1904] 448, also Bd. 13, p. 706.

[3] Ztschr. Hyg. u Inf. Krankh, 48, [1904] reviewed in Koch's Jahr. u. die Fort. in d. Lehr. Gährungsorganisme 15 [1904] 435. Beitrag zur Kenntnis der Nitrifikationsbakterien.

[4] Einwirkung des Hedrichs auf die Nitrifikation der Ackererde. Centbl. Bakt. [etc.] Abt II, 16 [1906], p 374.

[5] Zurmethodik der bakteriologischen Bodenunterschung. Centbl. Bakt. [etc.] Abt II, 16 [1906], p. 404.

Bazarewski[1] has shown a favorable influence of dextrose upon nitrification in a mixture of sand and loam.

Muntz and Laine[2] found that in liquid cultures nitrogen as ammonium humate was nitrified faster than nitrogen as ammonium sulphate and that in culture experiments a soil with a high humus content gave a more rapid nitrification than one of poor humus content.

Several investigators have noted great variability in the sensitiveness of the nitrifying organisms to inhibiting chemicals according to the vigor of the culture.

Chick,[3] working with sewage nitrifying organisms, found that although the nitro-bacteria when alone could not grow in bouillon that it was capable of surviving an inoculation into bouillon if in the presence of other bacteria. Further that a pure culture inoculated for four generations into bouillon was still capable of producing nitrification. She concludes:

"The amount of organic matter accumulated in a sewage filter is comparatively great, and it seemed most unlikely that nitrification should here also be the work of bacteria so extremely sensitive to the presence of organic matter.

"One is compelled to conclude, in explanation, that the presence of the accompanying organism in some way protects the nitrate bacterium from adverse influences present in the bouillon, which it is unable to withstand if alone."

Müller and Weis[4] have shown that turf with ammonium salts and lime added nitrify vigorously, nitrifying completely not only the ammonium salt present but also some of the nitrogen of the turf itself.

Still more recently Karpinski, A., and Niklewski, Br.,[5] in a carefully planned series of experiments, have demonstrated that various organic compounds in low concentration when used in mixed cultures clearly favor nitrification and have definitely shown by experiment that humus-rich soil nitrifies more actively than humus-poor soil.[2]

Coleman, Lescie C.,[6] in what is one of the most important of recent contributions to soil bacteriology) calls especial attention to apparent disagreement of Winogradsky's conclusion and the obvious condition of nature as well as to the fact that Winogradsky's work was conducted in fluid media. In his own experiments Coleman demonstrated that in a mixture of sand and loam, unsterilized, dextrose, cane sugar, glycerine and lactose each in small quantities hastens nitrification somewhat. That in pure cultures in sterile earth and sand, or sand alone, dextrose in small quantities favors nitrification. Nitrification in sand and in fluid cultures was compared and it was clear (p. 486) that an amount of dextrose that was inhibitive in the fluid was not inhibitive when in sand.

---

[1] Bazarewski, Beitrage zur Kenntnis der Nitrifikation and Denitrifikation im Boden. [Diss.] Gottingen 1906.

[2] Compt. Rend. Acad. Sci. [Paris] 142, [1906,] p. 430.

[3] Proc. Royal Soc., [London,] 77 B., pp. 243 and 517.

[4] Naturw. Zeitschr. Land u. Forstw. Bd 5 [1907], p. 232.

[5] Karpinski, A., und Niklewski, Br. Uber den Einfluss organischer Verbindungen auf den Verlauf der Nitrifikation in unreinen Kulturen. Extr. Bul. Acad. d. Sci. Cracovie, 1907.

[6] Coleman, Leslie C., Untersuchugen über Nitrifikation. Central Bak. Abt II, 20, 1908, p. 401.

Similar results were attained regarding nitrification, showing differences in the action of dextrose in sand and in solution.

Müntz und Laine,[1] studying this question to determine the best means of providing saltpeter for the manufacture of gunpowder, found that nitrification was favored by humus and they therefore selected peat "Qui est un milieu extremement riche en matieres organiques et humiques," as a material to support nitrification, in which they found nitrification to proceed very rapidly.

Lemmerman, Fischer, Kappen and Blanck[2] have shown that the amount of nitrification is largely regulated by the conditions of the culture and that different results are given in earth cultures from those attained by sand cultures or fluid cultures.

The results of preliminary work of Makrinow, A., are summoned up as follows:

Organic matter in the form of soil or of extracts from dry leaves or soil exerted a favorable influence in a liquid medium.[3]

Summarizing chronologically the results of previous work and of that reported in this article, the following evidence obtains to show that Winogradsky's laboratory results do not apply to field conditions:

"Most of the soils high in humus are high in nitrifying power." Withers and Fraps, 1903.

The organic matter in soil extracts with mixed cultures does not inhibit nitrification. Löhnis, 1904, and Gutzeit, 1906.

Organic matter sufficient for denitrification does not inhibit nitrification. Itersen, 1904.

Organic matter absorbed by pure sand is not so strongly inhibiting in its action as when in solution. Wimmer, 1904.

Nitrifying organisms can live and multiply in bouillon. Chick, 1906.

Nitrification is greater in soils of large humus content than in soils of low humus content. Buhlert and Fickendey, 1906.

Dextrose in a mixture of sand and loam favors nitrification. Bazerewski, 1906.

Nitrification can proceed more vigorously in Ammonium humate than with ammonium sulphate. Müntz and Laine, 1906.

Nitrification in mixed cultures is favored by small amounts of organic matter. Karpinski und Niklewski, 1907.

Nitrification can proceed vigorously in turf. Muller und Weis, 1907.

In both pure and mixed cultures dextrose, cane sugar, glycerine, and lactose favor nitrification if present in small quantities. The amount of dextrose necessary to inhibit is larger in sand than in solution. Coleman, 1908.

Organic matter exerted a favorable influence on the growth of the nitrous organism in a solid substratum, but an unfavorable influence in a liquid medium. Makrinow, 1909.

Nitrification with pure and with mixed cultures of nitrifying organisms is inhibited less by such organic matter as peptone, cottonseed meal or cow manure in soils than it is in solutions. Stevens and Withers, present article.

---

[1] Muntz et Laine, Recherches sur la nitrifikation intensive et l'establissement des nitrites a hauts rendements, Ann. Inst. Nat. Agron. Vol. II, p. 76 (1907) p. 3 f.

[2] Mitteilung de agrikultur chem. Versuchsstat. Berlin, Instit. f. Versuchswes. u. Bakteriol. a. d. konigl. landwirtschaftli. Hochschule. Bakteriolog. Chem. untersuchungen. Chem. bakteriolog. Teil. Landwl. Jahn. 38, p. 319.

[3] Veyestnik Bakt. (Agron. Stantzil V. K. Ferrein, 1908; No. 14, pp. 132-179; Abst. in Zhur. Opuitn. Agron.) (Russ.) Jour. Expt. Landw.) 10, 1909, pp. 427, 248).

To this it may be added that Gavinet and Chevrand, more than a hundred years ago, observed that large quantities of saltpetre commonly formed in stables where sheep and goats are kept, attributing this to the fact that sheep and goat dung, kept warm, thinly spread out, and occasionaly moistened with urine, conditions under which it is usually found, offer conditions fit for nitrification.[1] For many years it has been known that in the manufacture of saltpetre, nitrification occurs in very active form in the most of organic mixtures, flesh, urine, animal and vegetable matter of all kinds while in very recent years we have the thorough work of Müntz and Laine[2] showing rapid production of saltpetre in highly organic nitrifying beds.[3]

There are then clearly two fundamental reasons why the activity of the nitrifying organisms as studied in pure culture in the laboratory can not be compared with the activities of the same organisms in the field.

1 In mixed culture their symbolic and physiologic relations are so different from those obtaining in pure cultures that their metabolic processes are difficulty expressed.

2. The presence of large amounts of solid matter, sand or earth in contact with the liquid medium so alters its relation to the nitrifying organisms that their physiologic activities and metabolic products are different.

The explanation of these two facts is still far to seek, but it may be remarked that a pure culture of a nitrifying organism in an artificially prepared solution is an exceedingly unnatural environment for an organism residing naturally in soil with its manifold species, both animal and vegetable, and with a chemical and physical constitution whose intricacies we can as yet but vaguely surmise.

Possibly a study of other of our animal or vegetable friends under such abnormal conditions would lead to pictures equally wide of the natural.

CONCLUSION.

In the light of the facts set forth, the direct application of Winogradsky's conclusions to the field must be abandoned and with them any practices based upon them, and the activities of these soil bacteria must, in the future, be studied more largely under their natural environments.

Organic matter even to a large amount, as considered agriculturally, is not necessarily inimical to the functioning of nitrifying organisms in the field.

As the proof of the foregoing article reached us, came also the excellent work of Niklewski,[4] which substantially confirms our own results and presents an admirable historical review of the subject.

---

[1] Agriculture in some of its relations with chemistry, by Storer, F. H., Vol. I., p. 486.

[2] Munts and Laine, l. c.

[3] For a full description of these processes and history of the art, see Thiele, O., Saltpeter wirtschaft un. Saltpeterpolitik, (Zeitsch, f. d. gesam. Staatswiss. nd. 15, 1905.

[4] B. Niklewski Uber die Bedingungen der Nitrifikation in Stallmist Centbl. Bakt. Ab. II, 1910, (No. 26, p. 13-15).

THREE INTERESTING SPECIES OF CLAVICEPS.[1]

By F. L. Stevens and J. G. Hall.

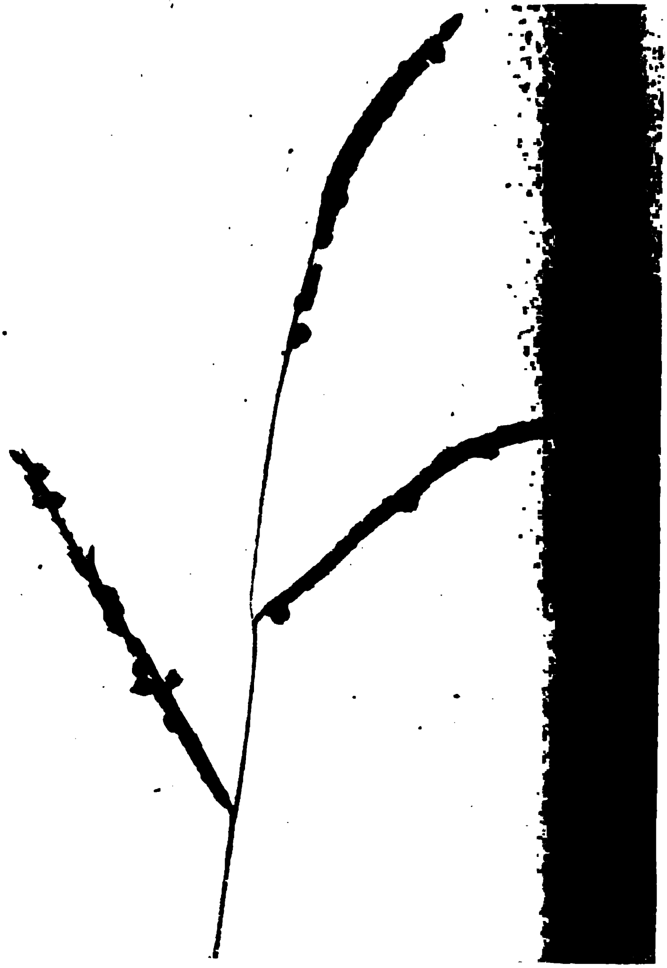


Figure 1—Sclerotia of C. Paspali as seen upon the host.

One of the fungi most commonly met in North Carolina occurs in sclerotial form upon Paspalum læve and P. dilatatum.[2] Over large areas every plant may bear spikes showing one or more of these sclerotia. In summer these are covered with a yellowish coat of spores and the fungus has therefore been variously designated as Sclerotium Paspali Schw. Spacelia Paspali Barnet, Spermoedia Paspali[3] Fr. The species was used extensively by the authors in a physiological investigation,[4] and is well represented in the accompanying cuts.

---

[1] Published in Bot. Gaz. 50: 460, 463.

[2] These species were kindly determined for us by A. S. Hitchcock.

[4] Farlow Host. Ind., p. 153; also Sacc. Syll. Fung. 14, 1152.

[3] Variation of Fungi due to environment, Bot. Gaz. 48: 1-30.

The abundance of the form and the fact that its perfect stage appeared to be unknown led us to attempt to grow from it an ascigerous stage. Numerous sclerotia which had wintered out of doors, naturally were collected from the ground where they had fallen and were planted on moist earth in glass capsules which were kept at room temperature. After 20 to 25 days signs of germination appeared Soon stalks from 5 to 18 mm. long developed and on their ends round heads 1-2 mm. in diameter. (Fig 3.)

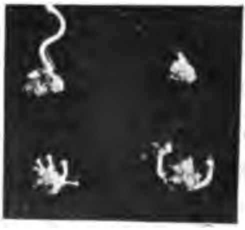


FIGURE 3.—Sclerotia of Claviceps germinated.

FIGURE 2.—Sclerotia of C. Paspali upon the host, enlarged.

By teasing or sectioning perithecia and asci of the typical claviceps form were found. But most remarkable two clearly distinct types of perithecia, differing strikingly in size and shape and bearing spores of decidedly different size were found. The perithecia of the two forms are shown in Figs. 4-5.

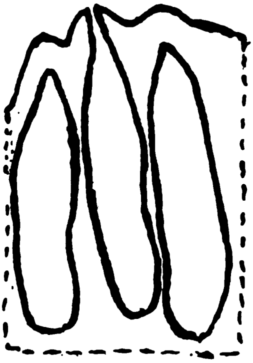


FIGURE 4.—Perithecia of C. Rolfsii (magnification as in fig. 11.)

In the collection of the U. S. Department of Agriculture were found sclerotia from Paspalum bearing asci. These proved to be identical with the small spored form of our own collection.

Correspondence between Prof. Rolfs and the Department of Arriculture which has kindly been palced at our service shows that Prof. Rolfs at Clemson in 1901 noted the ascigerous stage of sclerotium Paspali Schw. on P. dilatatum, and further observed that the ascospores were disseminated largely by beetles, principally of the family Carabidœ, which running over the ground came in contact with the spores and later in seeking a high point from which to fly would run up the culms, over the pistils and thus bring about infection of the ovaries.

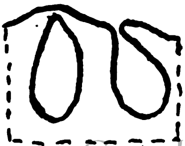


FIGURE 5.—Perithecia of C. Paspalis (magnification as in fig 10.)

Since the two species of claviceps under discussion differ markedly from any heretofore described, and from the only Claviceps upon Paspalum, (C. lutea A. Möll), and from each other in many essential characters, prominently so in length of

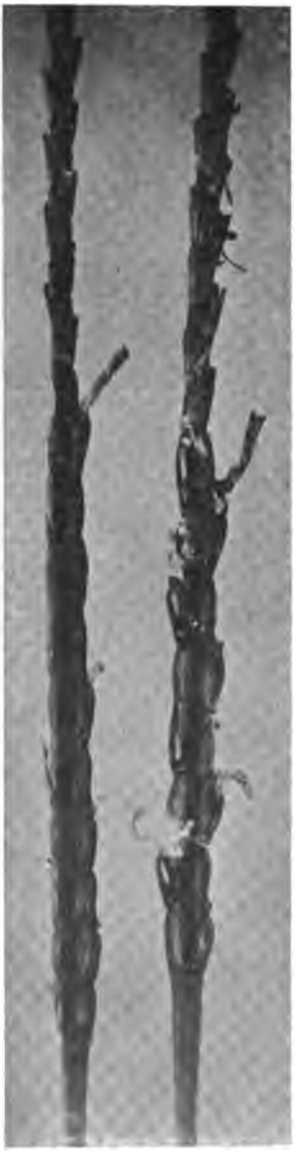


FIGURE 6.—C. Tripsaci upon the host.

stipe and size of perithecia and spores; we herewith propose them as new species; the small spored form as C. Paspali; the large spored form as C. Rolfsii. The relation of these two species of Sclerotium Paspali Schw. is not definitely known. Both of them are associated with what has heretofore been known as S. Paspali Schw. It therefore seems probable that two sclerotial forms very closely resembling each other have been comprised under the one name, Sclerotium Paspali, but careful cultural studies and infection experiments alone can reveal the true relationship. That Sclerotium Paspali really belongs to the form genus Sphacelia where it was placed by Bornet is also clear, possessing as it does small ovoid conidia borne upon simple, slender stalks.

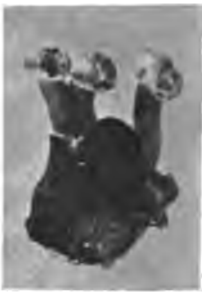


FIGURE 7.—C. Tripsaci: sclerotium showing heads and stalks X 2.5.

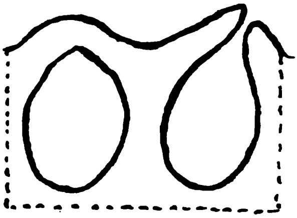


FIGURE 8.—Perithecia of C. Tripsaci (magnification as in figs. 10 and 11.)

Claviceps Paspali n. sp.—Sclerotia yellow to gray, globose roughened when mature, about 3 mm. in diameter; head dull yellow, stipe short to medium, usually not more than 1 cm. long, filiform; perithecia completely covering head, numerous, oval, 340 x 119 μ; asci cylindrical 174 μ long; spores filiform 101 x 1-2—1 μ.

Claviceps Rolfsii n. sp.—Sclerotia yellow to gray, globose roughened when mature, about 3 mm. in diameter; head dull yellow; stipe filiform but thicker than in C. Paspali 1-1.5 cm. long; perithecia few in head and mostly upon extreme distal portion, cylindrical ovate, 816 x 225 μ asci cylindrical 375 x 3 μ; spores filiform, 260-275 x 1-2—1 μ.

Upon Gama grass (*Tripsacum dactyloides L.*) in late summer and well into winter characteristic fungous growths are often seen protruding from the basal, ovulate, portions of the spike, sometimes nearly every spikelet being affected (Fig. 6). The structures are white from 12 to 20 mm. long, and about 2-3 mm. thick. Toward their tips they may be browned and more shrunken than in regions near their bases.

Examination of the affected spikelets shows the seed to be absent and its place to be occupied by a white sclerotium approximately the shape of the seed of the host. In general the appearance is that of a Claviceps sclerotium, except that it is white and soft, the protruding horn being the remnant of the summer stage.

Throughout the early part of the season the protruding part bears myriads of straight to lunulate spores, showing strong resemblance to the ordinary lunulate Fusarium spore. The internal portion remains sterile throughout the winter.

The appearance throughout was so Claviceps-like that sclerotia were collected in autumn and wintered in an open air hibernating house then planted for germination in the same manner employed with the Paspalum sclerotia. After some 20 days the emergence of ascophore stipes was noted and 5 days later the heads were well developed upon them. (Fig. 7.) A particularly striking feature is the tendency of the stipes to fork and produce two or even four heads upon the same stalk.

Teasing or sectioning showed typical Claviceps, perithecia and asci.

The species seems to be new and we described it as Claviceps Tripsaci.

Claviceps Tripsaci n. sp.—Sclerotia smooth, dark brown to black, nearly conical, 4-5 mm. in diameter at base; heads gray to grayish white, stipe thick, white to purplish white, 1-1¼ cm. long; perithecia numerous, elliptical in longitudinal section with a short beak toward the surface of the head, 390 x 153-187 μ; asci cylindrical 145-175 x 2-3 μ; spores filiform 130 μ long.

Conidia hyaline, continuous, fusoid, to lunulate 17.4-37.7 x 29-8.7 μ

MODIFICATION OF THE DIPHENYLAMINE TEST FOR NITROUS AND NITRIC ACIDS.

By W. A. Withers and B. J. Ray.

Diphenylamine was discovered by Hofmann[1] in 1864, and the blue coloration which he found that it gives with various oxidizing agents has since been used for the detection of the presence of minute amounts of nitric acid.

In 1872 Kopp[2] first proposed its use for the detection of nitrous acid in commercial sulpuric acid.

In 1875 Böttger[3] proposed that the reaction of Kopp be used for the detection of the presence of nitrites and nitrates in potable waters.

Since that time various chemists have given consideration to the subject and have proposed modifications of the method of applying the test—some of them being very delicate and others less so. It was the need of a reliable and delicate test for nitrites and nitrates which led us to take up this work.

For preparing the reagent Cohn[4] and Wiley[5] use diphenylamine and concentrated sulphuric acid and specify no relation between the amounts except that Wiley refers to 4 cc. of sulphuric acid. Fresenius[6] and Eggermainz[7] use 10 mgms. and Muller[8] 20 mgms. of diphenylamine to 100 cc. of concentrated sulphuric acid. Warington[9] dissolves in an indefinite amount of water and adds an indefinite amount of concentrated sulphuric acid. Lunge[10] and Treadwell[11] use 500 mgms. of diphenylamine for each 100 cc. of concentrated sulphuric acid and add 20 cc. of water. Hager[12] uses 1 gram to each 150 cc. of acid, and adds 30 cc. of alcohol, and Cimmino[13] uses 5 per cent hydrochloric acid without giving the relation between the diphenylamine and sulphuric acid.

The manner of making the test differs with different chemists. To 1 cc. of the liquid to be tested, the amount of diphenylamine reagent to be used is specified as "1 drop," "3 to 4 drops," "a few drops" and "5 cc.," and in some instances no amounts are stated. Some use also sulphuric acid in making the test. Some float the liquid to be tested upon the reagent, some mix the liquid and reagent and float the mixture over concentrated sulphuric acid, and Wiley[5] heats at 80 degrees for 15 minutes. Some simply say "treat" and give no details. The table given below shows these facts more in detail.

The manner of making the test is of considerable importance. When the amount of nitrate or nitrite is small it is possible to place the two liquids in layers without the development of a color. In this case the color will develop promptly upon gentle agitation which causes a slight mixing of the two liquids at the plane of contact. This blue band may be made to disappear entirely upon thoroughly mixing the liquids if the nitrates and nitrites are in small amounts.

An excess of diphenylamine over the amount required for the reaction actually retards or prevents the development of the coloration. This was shown by us in a series of tests in which varying amounts of the diphenylamine reagent were used. When we used one, two or three drops of the Treadwell [11] reagent 2 cc. of the liquid to be tested and 2 cc. of concentrated sulphuric acid we obtained a good ring, but when we used five, seven or ten drops of the same reagent and other conditions as before, no satisfactory coloration was developed.

The amount of sulphuric acid is extremely important and the addition to it of small amounts of a mixture of diphenylamine reagent and nitrate-bearing liquid which have not given the test will frequently develop a strong coloration.

Warington[9] in 1885 referred to the greater delicacy of the test in the presence of chlorides, and in 1899 Cimmino[13] proposed the use of 5 per cent hydrochloric acid either by adding a few drops of this acid in making the test or by adding this acid to the solution of the base in sulphuric acid. In a test tube he placed 1 cc. of the solution to be tested, 3 or 4 drops of the diphenylamine solution in sulphuric and hydrochloric acids, 2 cc. of concentrated sulphuric acid and shook. In any case the color develops gradually and reaches the maximum after some minutes; an elevated temperature hastens the development of the color. Practically any of the methods will show the presence of one part of nitrate nitrogen in 10 million.

Combining some of the features of the different methods we have prepared a reagent which in our hands has proven to be very delicate. It is made in the following manner: 700 mgms. of diphenylamine are dissolved in a mixture of 60 cc. of concentrated sulphuric acid and 28.8 cc. of distilled water. The resulting mixture is thoroughly cooled and 11.3 cc. of concentrated hydrochloric acid (sp. gr. 1.19) are added slowly—making the hydrochloric acid content 5 per cent. After standing over night some of the base separates showing that the reagent is saturated. The test with the diphenylamine reagent as prepared by us is conducted as follows: Place 1 cc. of the liquid to be tested in a clean test tube; add 1 drop of the diphenylamine reagent and mix thoroughly by shaking. From a pipette is added 2 cc. of concentrated sulphuric acid, while the tube is held at an angle so as to form two layers of the liquids. The tube is gently agitated so as to cause a slight mixing of the liquids at the plane of contact, and it is then placed in a bath at the temperature of 40 degrees and left for 15 or 20 minutes. This method will reveal the presence of one part of nitrite nitrogen in 25 million or one part of nitrate nitrogen in 35 million. By heating for one hour instead of 15 or 20 minutes the test will show one part of nitrite nitrogen in 32 million or one part of nitrate nitrogen in 44 million.

Chemist.	Reagent.				Reagent used—drops.	Solution of unknown used—cubic centimeters.	Sulphuric acid used—cubic centimeters.	Temperature, °C.	Time in minutes.	Procedure.	Delicacy claimed, 1 part of nitrogen to—
	Diphenylamine—milligrams.	Sulphuric acid—cubic centimeters.	Water—cubic centimeters.	Other substances.							
Treadwell[11]	500	100	20							Float liquid to be tested on the reagent	
Cohn[4]					few	1	1			Mix liquid and reagent, float on sulphuric acid.	13,000,000
Wiley[5]		4			1	1		80	15	Add 1 drop of reagent to liquid, keep at 80° for 15 min.	
Fresenius[6]	1	10			few					Float regent and liquid on sulphuric acid.	
Hager[12]	1,000	150		30 cc. alcohol						Float liquid on reagent.	20,000
Warington[9]					2	2	5			"Treat."	10,000,000
Muller[8]	200	1,000			*100	1				Treat 5 cc. of reagent with 1 cc. of unknown.	7,700,000
Eggermainz[7]	10	100			†200	several			20	'Treat."	44,200,000
Cimmino[13]				5% HC_1	3–4	1	2			Treat and shake.	1,000,000
Withers and Ray.	700	60	28.8	11.3 cc. HC_1 (1.19)	1	1	2	40	15	Float liquid and reagent over sulphuric acid, agitate gently. Keep at 40° for time stated.	35,000,000
Withers and Ray	700	60	28.8	11.3 cc. HC^1 (1.19)	1	1	2	40	60	Float liquid and reagent over sulphuric acid, agitate gently. Keep at 40° for time stated.	44,200,000

*5cc.
†10cc.

---

[1] Liebig's Ann. Chem. 132, p. 160.
[2] Ber. Deut. Chem. Gesell 5, p. 284.
[3] Jahresber Tier-Chem. 1875, p. 918.
[4] Indicators and Test Papers 1907, 68.
[5] Principles and Practices of Agricultural Analysis I, 532.
[6] Qual. Anal. Trans. 1906, p. 388.
[7] Bul. Soc. Chim. Paris, 1889, p. 350.
[8] Bul. Soc. Chim. Paris, 1889, p. 670.
[9] Chem. News, 51, p. 41.
[10] Ztschr. Angew. Chem., 1894, p. 345.
[11] Treadwell-Hall An. Chem., 1907, I, p. 340.
[12] Jour. Chem. Soc. (London) Abs. 1886, 50 p. 99.
[13] Ztschr, Analyt. Chem. 1899, 39 p. 429.

NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

By F. L. Stevens and J. H. Hall.

AMBROSIA.

Rhodochytrium.—In 1903 one of us (Stevens) noted in great abundance a peculiar distortion of the ordinary ragweed in the neighborhood of West Raleigh, accompanied by a close infestation of the plant with red Synchytrium-like pustules. Each year since, the same disease has been repeatedly seen in great abundance in various sections of the State, often so abundantly that its presence could be easily discerned from the window of the passing train. It has also been collected at the following points in North Carolina:

West Raleigh, Enfield, Polkton, Clayton, Cary, McLeansburg, Davidson, Mt. Ulla, Hiddenite, Taylorsville, Connelly Springs, Marion, Rutherfordton, Hendersonville and Auburn.

The fungus has been determined by both Farlow and Atkinson as *Rhodochytrium spilanthides* of Lagerheim, which is of peculiar interest both owing to its unique systematic position, its peculiar host relation and its geographical distribution. It has so far been collected upon only three hosts, two composites, *Spilanthes* and *Ambrosia,* and upon *Asclepias pumila,* and only in distant sections, viz.: Ecuador by Lagerheim in 1889, where diligent search failed to reveal it upon other hosts; in Kansas in 1904, by Bartholomew, whose specimens were determined by Farlow and later distributed in *Fungi Columbiani* as No. 2166; by Stevens in North Carolina, as above stated, and in South Carolina.[1] While this fungus was found upon *Ambrosia artemisiæfolia* in every locality in North Carolina where the trouble was taken to look for it, diligent search has failed to reveal it upon *A. trifida* throughout the same range though this host has been repeatedly and carefully examined.

Perhaps greatest interest attaches to the systematic position of this peculiar organism rejected as it has been by both mycologists and algologists, though at present regarded as an alga.

APPLE.

Ripe Rot (Glomerellose.)—This disease was noticed in very great abundance at all the many places visited on the Southern Railway between Goldsboro and Murphy. In many instances badly decayed apples were offered for sale in the stores. Many cases were noted of orchards which would have otherwise been profitable, but whose yield was entirely destroyed by this disease. This was particularly the case in Halifax, Randolph, Guilford, Davidson, Surry, Stokes, Catawba, Burke, Cherokee, Buncombe, Haywood, McDowell and Wake counties.

Clitocybose.—Death of trees in orchards in Haywood County was reported, and investigation showed the presence of a fungus which, to all appearances, was *Clitocybe parasitica.* This fungus is said by Wilcox[2] to be a true parasite and is presumably responsible for the disease in the present instance.

---

[1] Tufts College Studies, No. 3, p. 148. 1908.

[2] Okla. Sta. Bul. 49, 1901.

Rust.—Rust continues to be a most serious apple enemy in the Piedmont and eastern sections. It was noted in especial abundance in Clay, Swain, Wake, Mecklenburg, Forsyth, Guilford, Alamance and Caswell counties.

Hypochnose.—This disease, the subject of a special paper in our last report, is one of the most prevalent of apple diseases in the mountain section, often causing complete defoliation of whole orchards. It has now been seen in abundance in Duplin, Bladen, Surry, Yancey, McDowell, Rutherford, Henderson, Haywood, Macon, Madison, Clay, Transylvania, Jackson, Graham, Swain and Cherokee counties.

Powdery Mildew.—An unusual outbreak of this mildew upon mature apple trees was noted in the spring of 1910 in Wake County. Though this fungus usually appears in destructive form only upon nursery stock, in this instance terminal shoots for a distance of eight or more inches back from the tip were destroyed by the disease; the leaves dropping, curling and dying, meanwhile becoming thoroughly coated with the mildew. The disease was also reported from Johnston County.

Leaf Spot.—The common apple leaf spot continues to be very serious in all Western North Carolina when spraying is neglected. In the Eastern and Piedmont regions, this enemy is not so troublesome; the spots are much smaller and very little defoliation results. It has been collected in Cherokee, Graham, Swain, Macon, Haywood, Henderson, Buncombe, McDowell, Burke, Caswell, Catawba, Iredell, Rowan, Davidson, Forsyth, Guilford and Jackson counties.

Blight, Bacillose.—The blight, while not so destructive upon this host as upon the pear, is still serious in many instances. It was noted particularly in Caswell, Sampson, Iredell and Buncombe counties.

Scab.—Scab still prevails in all unsprayed orchards. It is seen in its most injurious form in spring when it is followed by soft rots. Most of the apples on sale are then rotted and show the scab at the center of the rot, marking the invasion point of the fungus.

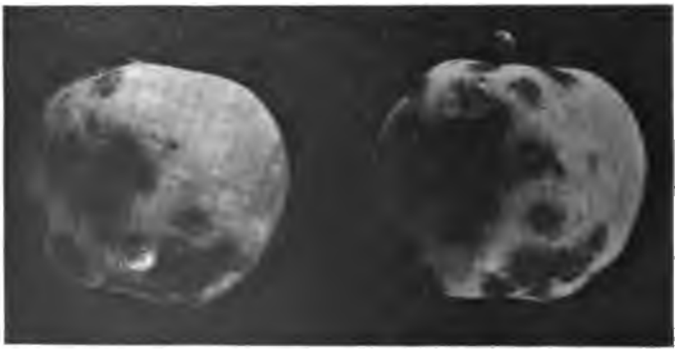


FIGURE 9.—Apple Blotch.

Bloch (*Phyllosticta solitaria.*)—This serious disease of the middle west has as yet caused no loss in North Carolina, but has been collected in small quantity chiefly as a bark canker from Surry, Guilford, Wake, Harnett and Edgecombe counties.

Black Rot.—Black rot has been collected in Guilford, Sampson, Catawba and Alexander counties.

Canker.—A canker of apple limbs, new to us has appeared in very destructive form during the past year. The disease is characterized as follows:

Upon the young twigs appear white or pinkish-white pustules. Upon closer examination the epidermis and the corky layer just underneath are seen to be wrinkled and separated from the rest of the bark. Then this thin layer of the bark splits open and exposes a brown surface. In many cases the epidermis does not split and the pustules are then produced at any point of weakness, as near the lenticels. Upon the older twigs the epidermis becomes wrinkled and later it cracks longitudinally and the fungus appears in rows of whitish pustules in the cracks.

In the majority of cases of affected twigs there is no external appearance of the fungus except the pustules, but in some instances there is a striking pinkish white mycelial growth over large areas of the surface of the bark. In some such cases the growth is smooth and forms a comparatively even whitish coat over the twig surface. In the other cases the mycelial covering of the twig is broken up into small areas; each area of the fungus being surrounded by a crack through which the bark may be seen.

Under the microscope the pustules are seen to be made entirely of mycelial threads, though their outward appearance leads to the thought that they are composed of a number of perithecia. This appearance is purely superficial.

In all cases the cambium under the diseased spots was dead, brownish, and in many cases the dark brown color extended considerable distance into the wood. Microscopic examination of this brown wood revealed the presence of a mycelium which agreed in every way with that found so abundantly upon the surface of the twigs.

The disease has been received only from Reepsville, N. C., on October 5, 1909, but its history was especially interesting in that it was noted by the owner of the orchard on one tree only in the autumn of 1908, and progressed rapidly through the orchard, taking thirteen trees during the succeeding twelve months, notwithstanding the fact that the owner cut out all disease that he saw and sprayed thoroughly with lime-sulphur.

The disease appears to be particularly aggressive and though as yet rare, apple growers should watch carefully for it and check its invasion upon its first appearance in the orchard and before it develops beyond control. It may infest but one tree the first year, but bring destruction to many trees by the end of the second year.

In all cases where the disease is seen the affected part should be cut out and burned, cutting well below the disease. Cutting out without burning is of no use. A good cleansing spray during the winter, either of lime-sulphur or Bordeaux mixture or simply bluestone, will also be of value.

Correspondence concerning this disease and specimens of it are desired.

ALFALFA.

Ascochytose.—This leaf spot we found in considerable abundance upon alfalfa on the Station farm, but it did not approach in injury the ordinary ravages of the usual leaf spot, Pseudopezizose. The fungus appears to be *Ascochyta Medicaginis* Bres., heretofore recorded only on *M. lupulina* and from Saxony.

Pseudopezizose.—This most common and serious of all alfalfa diseases has been collected in Orange, Durham and Wake counties.

Sclerotiniose (*Wilt.*)—Alfalfa suffering from typical sclerotiniose was received from Mecklenburg County. The plants were wilted and covered with a white mycelium which under culture produced the sclerotia of the disease.

Buckeye Powdery Mildew (*Uncinula flexuosa* Peck.)—This mildew was collected at Robbinsville in August. It appears to be rather common throughout the mountains, but owing to its very scant mycelium is not as injurious as are most of the powdery mildews.

CELERY.

Root Knot.—Root knot due to nematodes was injurious in Pender County.

Bud Rot.—Bud rot in which the heart of the plant became a soft slimy mass did considerable damage in Pender County. No fungi were present though bacteria were found in great numbers. The disease was probably of bacterial origin.

CARNATION.

Alternariose.—This leaf disease was of serious injury in some greenhouses. Thorough and frequent spraying with Bordeaux mixture is usually effective in checking its spread.

CHERRY.

Leaf Spot (Cylindrosporiose.)—This is very common and destructive, causing much leaf loss.

CHRYSANTHEMUM.

Rust.—This rust was noted in very abundant and destructive form on chrysanthemums near Raleigh. As seen from the upper surface the spots are pale yellow, definitely bordered. Seen from below, they are pale and bear in their centers the sori containing masses of cinnamon-brown spores. Badly diseased leaves turn brown, die and curl up. All of the leaves upon a plant are usually affected and the vigor of the plants and their productiveness of blossoms is greatly impaired. The disease in this particular locality was unknown prior to this year, and was in all probability imported upon chrysanthemums bought from a western state.

COLLARD.

Sclerotiniose.—Sclerotinia indistinguishable from that which causes the serious lettuce drop was found in one garden in Wake County.

CORN.

The rust is rather common but the loss caused is inappreciable.

COTTON.

Wilt (Fusariose.)—This, one of the worst cotton diseases, is continually spreading. Since it is a soil disease for practical purposes to be once infected is to be always infected. Its advent in a field is to be greatly feared. It has been seen in Davidson, Mecklenburg, Union, Scotland, Robeson, Johnson, Pitt, Lenior and Duplin counties.

Bacterial Spot.—This translucent leaf spot is very common, but is not seriously injurious.

Anthracnose.—The cotton anthracnose is spreading and bids fair to become a serious disease here as in Georgia. During the last year it was noted particularly in Halifax, Wake, Granville and Mecklenburg counties.

Boll Blight (Shedding.)—A serious blighting of bolls was noted in the autumn of 1909 in cotton in the Experiment Station farm.

Bolls at various stages of development but mostly before a size of a half inch in diameter had been attained were completely blighted and dead. The blight extended to the bracts and the pedicil. Sometimes the pedicil separated from the stem at the abscissa layer and no disease was apparent upon the stems; but more usually the bark and wood near the juncture of the leaf and stem were diseased to a distance of one-half to one inch. The line of demarkation between sick and healthy

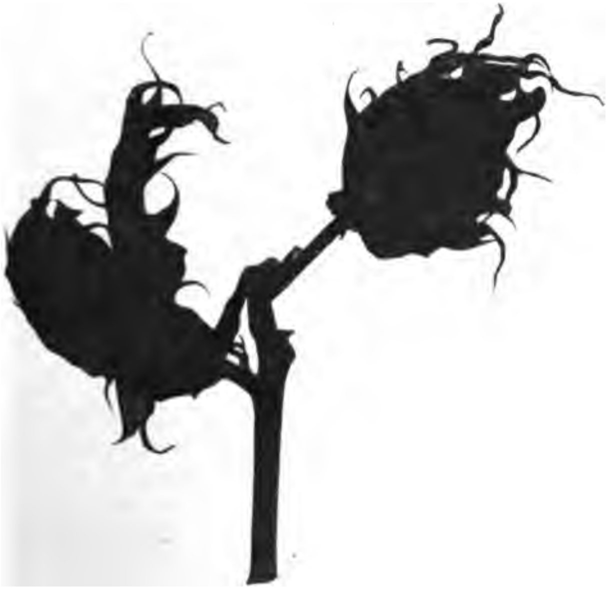


FIGURE 10.—Cotton "Boll-Shedding."

tissue was sharp, the healthy part outgrowing and thus tearing away from the sick and leaving a crack in many cases.

Specimens of the diseased parts which were placed in culture dishes in many instances developed a profuse growth of pinkish spore-masses which upon examination proved to be spores of the cotton anthracnose. It is probable, however, that this fungus was merely a secondary saprophyte and that the disease was that to which Atkinson called attention under the name of "shedding," and which he attributed to sudden flucuations in available water, to change from drought to wetness or wetness to drought.

COWPEA.

Mildew (*Erysiphe polygoni.*)—The mildew of the cowpea was unusually abundant last fall. Many fields showed hardly a single leaf free from its dusty white coating. The growth of the plant is appreciably retarded by this fungus and in some seasons considerable loss is caused by it.

Wilt (Fusariose.)—The cowpea wilt was noted this year in Wake and Wayne counties. It has previously been seen in Cabarrus, Mecklenburg, Cumberland, Johnston, Camden and Pasquotank counties.

CRIMSON CLOVER.

Sclerotiniose.—Typical specimens of this disease were received from Alamance County. It was reported that dead patches appeared throughout the field and that the disease spread rapidly. Specimens were received and cultured in the laboratory where inoculated plants rapidly succumbed to the disease.

DAHLIA.

Oidiose.—A powdery mildew was found quite common upon dahlias in Wake County, affecting particularly the lower leaves late in the season. No winter spores were present and a complete identification of the disease, therefore, was impossible.

EGG-PLANTS.

Wilt.—At the test farm of Hugh McRae, near Wrightsville, a wilt disease of egg-plants was noted in very destructive form in July, 1908. The plants exhibited the characteristic symptoms of all wilt disease, a wilting and drooping of the leaves and the eventual death of the plant. Examination of the stem in cross-section showed the usual blackening in longitudinal strands and the root showed the rot characteristic of wilt-diseased plants. While microscopic or cultural tests were not made it is nearly certain that the disease was the wilt so common on solanaceous plants, caused by *Bacillus solonacearum.*

The gardener in charge related that plants grown this year in portions of the farm where no egg-plants had been raised before did not suffer nearly to such an extent as did plants raised where egg-plants were grown last year and where a slight amount of disease was noted last year. The disease thus in this instance behaves in the manner typical of wilts in that it attacks the susceptible crop on its first planting to slight extent and increases to very destructive proportion the second year.

Count was made of several rows in portions of the farm not before planted to egg-plants with a finding of 24.5 per cent affected. Fields bearing egg-plants last year showed 84.3 per cent of disease this year. In nearly every case plants counted as diseased were entirely dead, in every case they were entirely unproductive and the per cent affected is really the per cent of loss.

FIG.

Rust (*Uredo Fici.* Cast.)—This fungus while old and reported in North Carolina a long time ago by Ravenel, is not frequently brought to the attention of the Experiment Station. Specimens were received, however, this year from A. B. McCallum, Red Springs, from plants which were suffering seriously from the rust.

Recommendation was made that the leaves of the affected bushes be raked up and destroyed in the fall, the ground turned over in the spring and the bushes well sprayed with Bordeaux mixture—before the opening of the buds in the spring.

GINSENG.

Alternaria and Microsporium did some damage to this crop in Swain County.

GRAPE, SCUPPERNONG.

Black Rot.—While not destructive on this grape and almost never seen on the fruit, this rot commonly occurs, forming scattered brown to black spots upon the leaves. It has never been noted, however, in such abundance as to cause alarm.

Black Rot was collected in Anson, Columbus, Pender, and Wake counties.

The black rot, the universal and worst grape disease of the State, was collected on bunch grapes in Alexander, Burke, Mecklenburg, Moore, Wake, Durham, Wayne, Edgecombe and Chowan counties.

GRASS.

Peculiar cases of grass injury by overgrowth by a slime mold were noted in Haywood, Wake and Granville counties. Similar outbreaks have been mentioned in other States and by McAlpine in Australia.

JAPAN CLOVER.

Mildew.—This valuable forage plant is often badly mildewed, especially in shaded localities.

LILAC.

Hypochnose.—This disease which primarily affects the apple was found in abundance upon the lilac in our mountain valleys.

MAPLE.

Tar Spot (Rhytizmose.)—This was brought into the laboratory on March 18, 1910, after it had wintered out doors. In working over the

Google

material it was noticed that the spores were discharged forcibly from the asci. Upon a spotted leaf being exposed to draughts or currents of air or upon blowing upon such leaves clouds of spores were discharged and remained visible for a distance of 6 to 8 inches from the leaf.

PEACH.

Cladsporium (Scab.)—This is present widely and does much injury.

Sphæropsose (Canker.)—This form of canker upon the branches is frequently met. During the year specimens have been received from Rowan, Cumberland and Mecklenburg counties.

PLUM.

Rust.—*Puccinia pruni* was collected in Wake County.

Black Knot.—This is particularly bad in the western part of the State.

PEANUT.

Cercosporose.—This leaf spot is circular in outline, indefinitely bordered, blackish-brown in the center and grading to green on its outer edge. The lower leaves are first affected and suffer most from the disease, later the disease spreads to upper leaves. The leaves begin to fall away soon after they spot and in many cases the death of the plants results. This disease has been sent to the Station for determination only a few times, but has frequently been seen at various localities. A

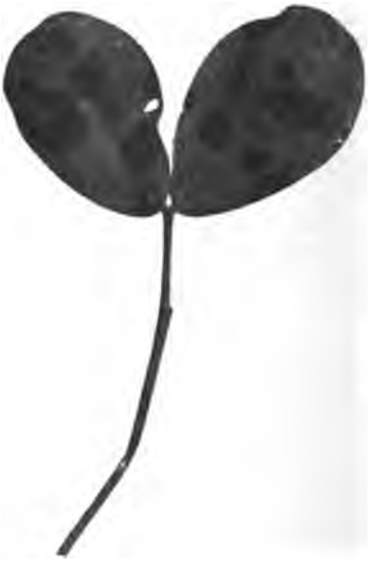


FIGURE 11.—Peanut Leaf-spot.

letter accompanied by specimens from Mr. Dunn, of Scotland Neck, states that "nearly all the peanuts throughout this section are affected in this way." It is often a serious pest especially in the eastern section of the State.

The disease is caused by *Cercospora personata* (B & C) Ell. The spores are produced in great abundance upon the diseased leaves and, carried by wind, spread the disease to other plants.

The fungus causing this disease was first collected in Carolina and Alabama by Ravenal.

POTATO, IRISH.

Black-leg.—From two sources, Cabarrus County, August 23, 1909, and Robeson County, May 3, 1910, came evidence of the occurrence in this State of what is in all probability the disease which has been attracting attention during very recent years in other States and abroad and which in this country is called black-leg and in Germany the equivalent term, Schwartzbeinigkeit.

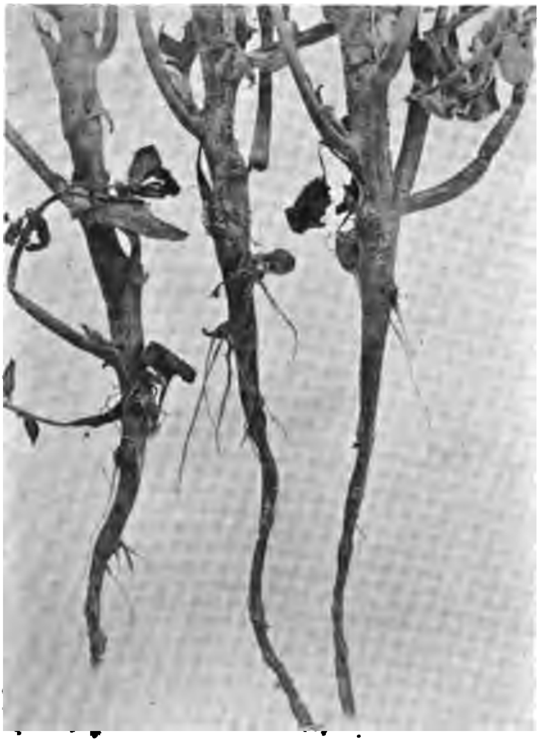


FIGURE 12.—Potáto Black Leg.

The disease in Cabarrus County was not examined in the field but was sent in with complaints of damage done. In all of its characters as observed in the laboratory it agreed with the Robeson County specimens described below.

The affected fields in Robeson County near Lumber Bridge, were visited by F. L. Stevens in May, and a disease fully agreeing with the description by Jones[1] was found.

The affected plants when well advanced in disease could be readily recognized at a distance by their lack of green color, the color varying anywhere from the slightest paling, a justly barely perceptible lack of full green, to a very marked and distinct yellowing. The different degrees of discoloration indicate different stages in the advancement of the disease and those plants that are but slightly discolored rapidly advance to a stage of yellowing, then die.

As the disease advances the leaves as they wither roll inward, that is, toward their dorsal surfaces, but any marked narrowing of the plant aspect, due to abnormally erect position of the leaves, such as is mentioned by Jones was not conspicuous if present at all. A few of the lower leaves may die before the top becomes entirely yellowed.

If the diseased stalk be pulled it is found that nearly or quite all of the underground portion of the stem and occasionally a half inch or so above ground is much blackened. In older cases it is coal black, shriveled and hard. In younger cases the color is nearer to brown and the stem is somewhat translucent. So far as our observation goes the disease always passes from below upward. No cases were seen where the upper part of the stem was diseased and the region near the stem's lower end was healthy.

Section of the stems of yellowed plants show the pith decayed and the stem to be hollow throughout considerable of its length, throughout all of the portion which was blackened externally and often several inches above the uppermost point of external blackening.

The main point of attack, however, is the woody cylinder surrounding the pith. This region is first affected and condition of disease in it denoted by a yellowing or even a blackening or internal pith decay. Either cross or longitudinal sections reveal these darkened woody strands extending far up into the tops and leading out into the leaves. By the time the tops are entirely yellowed this discoloration of the woody part of the bundles is evident almost or entirely throughout the plant. In the youngest condition noticeable at all in the field by very slight foliar discoloration these darkened woody strands are clearly apparent for considerable distance above the ground line. In its general anatomical effect this disease bears a striking resemblence to the Granville tobacco wilt.[2]

Young potatoes unaffected by diseases were frequently found still hanging upon the diseased portions of the stems though their further growth was of course precluded by the death of the supporting stem. In nearly, if not quite all cases of this disease, the seed potato is soft and rotten while the "seed" from which healthy plants have come is normally sound.

Microscopic examination shows the early signs of disease to be limited strictly to the veins and in them to the ducts, one, many or nearly all of which, according to the age of the cases may be browned.

---

[1] Vt. Sta., Rpt. 19, p. 257, and U. S. Dept. Agr. Bur. Pt. Ind., 87: 17, 1905.
[2] N. C. Sta., Bul. 188.

The diseased ducts bore innumerable hosts of bacteria. Examination of sections or of teased material showed these issuing in myriads into the surounding water. No fungi were observed.

The amount and destructiveness of the disease in this state is not yet known. Mr. Cobb, of Lumber Bridge, states that he saw the disease last year and estimates that it then decreased the stand in his fields perhaps 10 or even 15 per cent. At present the damage is less but since the vines will continue to die for some weeks yet, the damage can not now be satisfactorily determined.

While black-leg has not been very damaging in the North it is known to be more injurious when in the South and it may, during seasons suited to its development, prevail as a widespread and destructive disease.

The first definitely recorded recognition of Potato Black-leg in America was that of Jones in Vermont in 1906.[1] It is possible, however, that a disease reported by Clinton in Connecticut[2] in 1903 as the Southern potato blight was in reality black-leg.[3] The disease, however, was carefully described in Germany as early as 1903 and was known in England soon after that time. In America it has already been reported in South Carolina, Virginia, Maryland, New York, Colorado, Ohio, Rhode Island, Vermont and Maine, and possibly in Connecticut and Oregon. Two diseases which quite closely resemble black-leg, have been described, one by Harrison attributed to *Bacillus solanisaprus,* as prevalent in Canada, the other by E. F. Smith and others, attributed to *Bacillus solonacearum,* and known to occur extensively, especially over the southern States. In many of their symptoms all three of these diseases agree and until a comparative study of them side by side has been made the last word regarding their relations to each other can not be said.

The disease at present under discussion differs from the southern tomato blight (caused by *Bacillus solonacearum*) chiefly in the inky black lower stem, a character which is not mentioned as pertaining to the southern blight, while it differs from typical black-leg in the bundle discoloration.[4]

Prof. Morse, of Maine, who has had large experience with black-leg, and to whom we submitted specimens of this disease, writes as follows[5]:

"As far as I can judge from preserved material the lower parts of the stems sent correspond exactly with the appearance of the black-leg as it occurs in Maine, although I have never seen anything just like this where the blackening extends up into the top and leaf stalks, cropping out apparently at the nodes. However, under rather wet conditions I have seen the blackening extend up the stem some distance, even to the lower branches. I am inclined to believe, however, that this is exactly the same trouble which we have, but a little more extensive development of it resulting from different climatic conditions."

---

[1] L. R. Jones, Burlington, Vt., l. c.
[2] Conn. Sta., Rpt. 1903.
[3] Me. Sta., Bul. 174.
[4] Vt. Sta. Rpt. 19, p. 260.
[5] Letter of May 11, 1910.

Whatever the disease in hand may be it certainly bears close relation to black-leg and shows every indication of being seed-borne.

It will be well, therefore, for all potato growers to adopt the preventive measures suggested by Morse,[1] which are as follows:

First. Select seed, if possible, from fields upon which the disease has not appeared. Second, discard for seed purposes all tubers which have wounds, cracks or decayed areas. Third, disinfect all seed tubers with corrosive sublimate or formaldehyde before cutting. Spreading the seed tubers out in thin layers in a clean, dry place exposed to the direct rays of the sun for several days would be an excellent supplementary practice and tend to hasten germination as well. The disinfection of seed tubers and the rejection of all such as show blemishes or diseased areas will not only prevent the spread of black-leg, but also the propagation and spread of scab and most other tuber diseases which attack the potato in Maine.

Among the most important publications upon this disease in America are Buls. 149, 164 and 174 of the Maine Station; and Report 19, (1906), of the Vermont Station.

PRIVET.

Root Rot.—Privet plants of a hedge at West Raleigh were noted to be suffering from a disease which manifested itself by gradual paleing of the leaves, diminution of growth, and eventually by the wilting and dropping of the leaves, and finally by death. Plants showing these symptoms, which are dug up at the stage of the wilting of the leaves, showed the existence of rot in the cortex of the roots. Nearly all of the roots were affected and the cortex of the roots was softened, cracked in places and was permeated throughout with an abundant growth of mycelium. Since no functification was found identification of this fungus was impossible.

QUINCE.

Blight (Bacillose.)—The blight was observed in Buncombe County.

Rust.—Collections were made in Moore County.

ROSE.

Powdery Mildew—It is the worst out-door enemy of the rose. Numerous letters are received yearly concerning it. Specimens were collected this year in Warren, Granville, Randolph, Mecklenburg, Iredell, Robeson, Burke and Alexander Counties.

OATS.

Powdery Mildew (Erysiphose.)—In early spring, March, 1910, considerable injury of oats by this mildew was noted. The leaves were freely spotted in a way nowise resembling the usual mildew spots, each spot bearing much closer resemblance to a rust sorus than to a mildew spot. The spots were linear about 1 mm. wide and 2-3 mm. long, definitely bordered and showed to the naked eye no superficial white mycelium, though they bore somewhat scanty growth of conidia. The surrounding area was yellowed and the lower older leaves were in many cases killed by the fungus. Later the perithecia and immature asci were found upon this host.

---

[1] Me. Sta. Bul. 174, p. 323.

SORGHUM.

Sphacelotheca Sorghi, the cause of the smut so serious in some States, was collected in only one instance upon this plant.

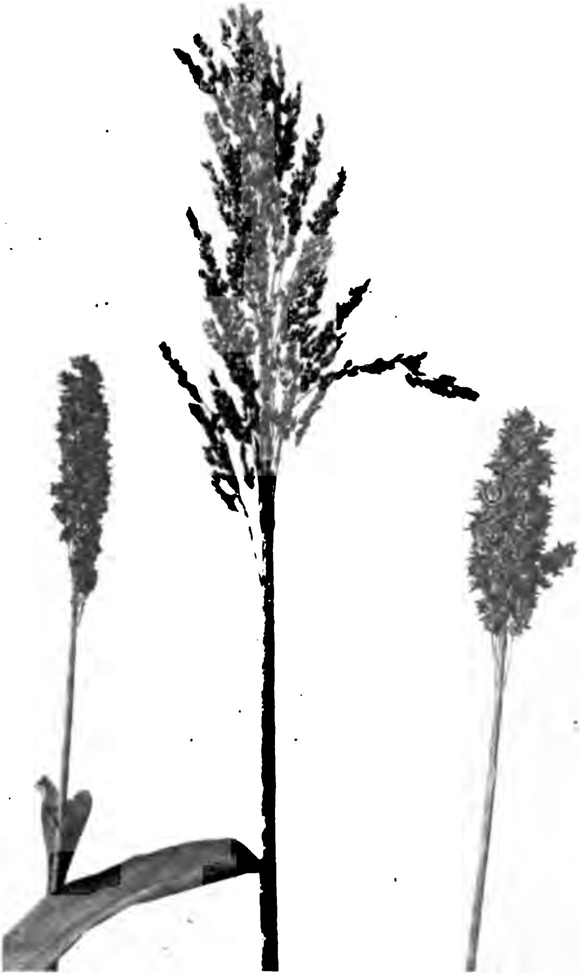


FIGURE 13.—Sorghum Panicles, Sphacelotheca.

Colletotrichose (*Colletotrichum falcatum* Went.)—This disease was first found in America upon sorghum in North Carolina where it did considerable damage. It is worse upon the lower leaves, producing characteristic spots. The spots have a very definite gray or tan colored center which is surrounded by a dark reddish-brown ring, outside of which is the ordinary green of the healthy leaf. As the spots age they frequently grow together and form one large oblong spot sometimes several centimeters long. At this later period in the development of the disease the centers of the spots are occupied by small black specks, the acervali of the causal fungus.

TOBACCO.

Thielaviose (*Thielavia basicola* Zopf.)—Specimens were received from Durham County with the complaint that the plants did not make normal growth after setting and that the roots were black. Upon examination the trouble was found to be caused by a fungus called *Thielavia basicola,* which attacks the roots. As this seems to be a trouble arising chiefly in the seed bed it probably can be avoided by burning new ground each year for the bed. Great care should be taken to discard all plants that show signs of the disease at time of setting.

Wilt.—This Granville tobacco wilt continues to levy upon new ground in Granville County, where it constitutes one of the most serious of crop problems. Specimens from Vance County have also been received. Three counties of the State are now known to be infected, Vance, Durham and Granville.

TOMATO.

Wilt (Bacillose.)—This wilt is very widespread and, like other soil diseases, retains hold of soil once infected. New counties in which it has been collected are: Durham, Sampson, Columbus, Duplin, Carteret and Alexander.

VIBURNUM.

The Hypochnose of the apple was found in several instances upon this host.

WHEAT.

Mildew.—Powdery mildew was found upon the leaves of wheat in Wake County, where it killed the leaves earlier than they would have died naturally. The perfect stage of this fungus was found upon the leaves of wheat taken from the field at harvest time.

Bunt.—This appeared upon wheat sown at the Poultry Division of the Station and in very bad form. Actual count of several thousand heads taken from the field showed an average of 10 per cent of diseased heads. The damage from this disease follows largely from depreciation in milling quality of the bunted wheat.

Some Breeding Experiments in Progress

Biological Division

BY F. L. STEVENS AND J. G. HALL.

MELONS.

I. The object of this work is to secure a variety of watermelon resistant to the widespread and constantly increasing watermelon wilt and at the same time of edible and commercial quality.

II. Several years ago watermelons were crossed on citrons, hundreds of crosses being made.

III. In this way several varieties of high resistance to the disease were secured. By seed selection during each of the succeeding years, the edibility has been increased and the resistance retained so that last year we raised melons in condition of nearly perfect health on land on which all ordinary melons would have died. Our crop gave a very large per cent of melons of high quality, thoroughly edible and excellent.

TOBACCO.

I. The object to secure a commercial tobacco which will grow on soil infected with the Granville Tobacco Wilt.

II. After many tests a variety of Sumatra was secured which showed considerable resistance. By continued selection and crossing the attempt is being made to secure a commercial resistant strain from this.

III. The results are yet uncertain.

Agronomic Division

BY W. C. ETHERIDGE.

WHEAT.

The purpose of the work with wheat is primarily to show the effect of seed selection, such as may be practiced by the farmer, on yield. It is also planned to determine by comparative field tests whether the initial selection and subsequent multiplication of the one best plant is as effective in producing improvement as continuous yearly selection. The work was begun in 1908 with field selections from a number of varieties grown on the Station farm and continued through 1909, multiplying seed of the initial selection plots and re-selecting from the continous method plots.

Although the work is as yet only in its beginning, results thus far noted are encouraging, as considerable improvement is apparent under both methods of selection. Hitherto, the plot areas used have necessarily been limited, but these will be enlarged in 1911, and the work continued on a more extensive basis through a sufficient number of years to substantially compare the two methods of selection, and the yields from either method with those from unselected seed.

COTTON.

Work begun with cotton in the fall of 1908 includes individual plant selections made in the general crop and the variety plots for length of staple, earliness, prolificacy, size and uniformity of bolls, double and triple-bolled plants, disease and drought resistance; also for combinations of some of these characteristics. The selections were made with the idea of obtaining improved strains of the parent varieties and to secure excellent pure-bred stocks for cross-breeding, by which method a trial will be made to produce new and desirable varieties. A comparison will also be made with cotton, as with wheat, of the methods of initial and continuous selection. Improvement of the general crop was also begun by selecting enough seed from plants of a generally superior type to plant a small area in 1909. Continuous selection will be the plan of this improvement, taking seed from the few best plants in the breeding plot with which to continue it the following year, using the remainder of the seed for planting the main crop.

Some very fine plants were produced in 1909 from the selected seed, and additional selections were made for the same qualities mentioned above. Especially promising were some of the plants resulting from the selections for prolificacy, earliness, disease and drouth resistance. It is planned to begin cross-breeding during the season of 1910 with those plants exhibiting the most desirable qualities, trying to secure combinations that will preserve in the progeny the best features of the parent varieties. When the crosses have been effected, and the desirable strains isolated, they will be tried out in a comparative test along with established varieties, and the strains resulting from straight selection.

Animal Husbandry Division

By R. S. Curtis.

SWINE.

OBJECT OF WORK.

To demonstrate to farmers and breeders of live stock, in this particular case with hogs, the practicability of using pure bred males on common "scrub stock" for the purpose of improving the type and increasing the general usefulness of the hog in the breeders' and feeders' domain.

METHOD OF CONDUCTING EXPERIMENT.

The experiment is being conducted on four scrub females, these having formed the foundation for the first-cross with a pure bred Berkshire male. One selected female pig from each of the four litters was reserved for the second cross and the remainder used for other purposes. The four pigs selected for the second cross have each been bred to a Berkshire male. This method of procedure will be continued until five crosses have been made, when it is hoped that the improvement will be sufficient to warrant the publication of a bulletin on the subject.

Photographs of each of the foundation animals and of the grade animals are being kept for future reference. From these the gradation from the inferior stock toward the ideal animal can be studied with considerable satisfaction. Two crosses have already been made and the selections for the third generation are showing every evidence of decided improvement over the foundation animals and the half-bred Berkshire stock.

RESULTS SECURED AND THEIR INDICATED PRACTICAL BEARING.

The results secured to date have been highly satisfactory, both in the improvement of type and the increase in weight at stated ages as compared with that of former crosses. In one case, the second cross has failed to remove all of the red color of the original stock. Otherwise, the characteristics of the Berkshire have been stamped on the progeny of the second generation. The body of the animals on the whole has been improved, by giving more length, depth and width. The characteristic long nose has been removed to a large extent, the head broadened, and the narrow, flat rib much broadened and deepened.

Taking the work as a whole some very striking improvements have been made. Some of the barrows which were turned over to the butcher were found to be very desirable market types in every respect.

Poultry Division

By J. S. Jeffrey.

Two lines of breeding work are being conducted with poultry at the present time.

First: Breeding for increased egg production.

Second: A study of the effect of in-breeding.

The object of the first is to determine if the average egg production of the flock can be increased by breeding, or if the ability to produce a large number of eggs is inheritable or can be transmitted from parent to offspring.

In this work we keep records of the number of eggs laid by each hen during the year. From all hens that make an average egg yield by the breeding season eggs are incubated, a record kept of the fertility, number of chicks hatched and number alive at four weeks old.

All chicks are banded when hatched and a record made of their numbers so that their parentage and date of hatching can both be determined.

At the present time we have no conclusive evidence that the quality of heavy egg production is inheritable. It has been found that in almost every case the daughters of hens making the best records have been poor layers. One family has been established which is giving better results than the average, but no remarkably heavy layers.

At the present time our experience would indicate that for the farmer and practical poultryman it is more important and profitable to make rigid selection for constitutional vigor and strength in the breeding stock than to select from the heaviest layers.

The second line of breeding work, that of studying the effect of inbreeding is being studied to determine if the popular objection to this plan of breeding is well founded or is mere prejudice. Many poultrymen and farmers on account of their objection to in-breeding, not only refuse to keep pure bred stock, but use males of a different breed each year to make sure that there is no chance of in-breeding. They thus lose all chance of having any uniformity, either of type or color, in their flock and also in the eggs produced.

In conducting this work two distinct strains of Barred Plymouth Rocks are being used. These will each be kept pure and crosses will be made of the two strains from time to time as a check mating.

North Carolina Agricultural Experiment Station

West Raleigh

C. B. Williams, Director.

Press Bulletin No. 21—September 15, 1909

TREATMENT OF OATS, WHEAT, RYE AND BARLEY FOR SMUT.

Very few farmers realize the full extent of the injury suffered by these cereal crops through the inroads of smut. The smutted plants are dwarfed, therefore escape observation so completely that even very observing farmers often allow as much as 25 per cent of smut to pass unnoticed. Smut is rarely less than 10 per cent in oats, and is frequently 16 to 25 per cent. This is a complete loss to the farmer, as it costs as much in seed, land and tillage to raise the smutted plant as to raise the full head. All of this loss can be turned into a clear profit at a cost of about one cent per acre for material and a very slight outlay of labor. The United States is suffering annually a preventable loss of about $18,000,000 from the smut of oats alone. Our own State is yearly losing between 10 and 20 per cent of her annual oat crop, which was valued at $1,797,000 in 1907.

RATIONALE OF TREATMENT.

The smut of grain is caused by a fungus, the spore (the reproductive body of fungi, corresponding to the seed in higher plants) of which is carried in the seed to young grain plant. Smutted plants in the field, and in threshing, shed their spores in the air. These spores are then carried about by the wind, many of them finding lodgment in the seed of neighboring plants. They are thus planted with the grain, and the same moisture, warmth, etc., which start the plant into renewed life quicken the smut. It thus happens that many young plants are, in earliest infancy, attacked by the smut enemy, which, having gained entrance, lurks within the plant until blooming time, when it again breaks forth in its well-recognized form. Only very young plants are susceptible to attack of the smut; therefore, if we can so treat the seed of the plants as to destroy the adhering spores of the fungus without injuring the grain, we can enable the young plant to pass the critical stage of its existence in safety. It is thereafter safe. Such treatment is possible. Smut can, therefore, be practically eliminated from the field. Several kinds of treatment are effective, but of all those known, that by formalin is by far the best and cheapest, although the familiar bluestone treatment is quite efficient in wheat.

TREATMENT.

Formalin can be purchased from a druggist at a cost of from 75 to 90 cents per pound. One pound mixed thoroughly with forty-five to fifty gallons of water is sufficient to treat forty-five to fifty bushels of grain.

To treat the grain, spread it in a thin layer on a smooth barn floor and sprinkle with the diluted formalin, using either a spraying machine or a watering-pot. Sprinkle so as to thoroughly and evenly wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution and cover the pile with canvas, carpets, blankets, or bagging, to keep the fumes of the formalin within. The pile should stand from six to twelve hours in this way. The oats may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning-mill, or the lime may be omitted if desired. It is merely a drying agent. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection. The best way is to treat, dry, then sow as soon as is practicable.

In general, one gallon of mixture will suffice to treat one bushel of grain. The formalin should be used at the rate of one ounce to three gallons of water.

Formalin is an irritating caustic, which should not be brought into contact with the skin in pure form. In diluted condition it is harmless.

If you try this treatment simply as an experiment, sow the treated seed in a definitely marked portion of your field, using all care to keep the treated seed from smutted seed. If you are adopting this treatment for your whole sowing, it will be instructive if you will leave a small portion, say one or two drill rows, with the same seed, untreated, thus enabling you to determine the real value of treatment.

We would be pleased to have you send a letter to the Station stating the results of your treatment, its cost, labor involved, amount of smut in treated and untreated fields. The amount of smut should be very carefully estimated in per cent from an actual count in the field.

F. L. STEVENS,
Biologist.

BULLETIN 205 JANUARY, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

INSECT ENEMIES OF CANTALOUPES, CUCUMBERS AND RELATED PLANTS

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	LOCKE CRAIG	Asheville

STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

INSECT ENEMIES OF CANTALOUPES, CUCUMBERS AND RELATED PLANTS.

By R. I. Smith, Entomologist.

Successful, profitable growing of cantaloupes, melons, summer squash and cucumbers is frequently rendered extremely difficult, or prevented, by the presence of destructive insects. The list includes nearly a score of different species which may at times become troublesome, although the chief damage is caused by only a few principal offenders, such as cutworms, striped cucumber beetles, squash bugs, melon lice, squash vine borers, and the so-called melon worms. The latter destroy the half-grown or maturing fruit and the opening leaf and blossom buds, while the others mentioned prevent or hinder proper growth and development of the plants from the time they commence growth. Truck growers who raise cucurbit crops for market have been forced to learn and practice methods for preventing or controlling these insects in order to obtain remunerative returns for their labor; farmers and amateur gardeners, attempting to raise these crops for home consumption, are too often inclined to give but slight attention to the insect pests, seeming to consider the resulting injury unavoidable, as many look upon the house-fly and mosquito nuisance. Twenty years ago such an attitude toward insect depredations was somewhat pardonable; but, considering the information now obtainable, failure to wage an intelligent warfare against insects becomes less excusable, and virtually an offense against others in a community who do exert their energies towards reducing the annual loss. With this thought in the writer's mind the present Bulletin is prepared with the hope that its readers may benefit by the suggestions made herein, and thereby be encouraged to not only raise larger and better yields of cucurbits for market or home consumption, but also, by retarding the annual increase of these insect foes, make the undertaking easier in coming years.

This Bulletin is intended for the benefit of those who grow a few cantaloupes, cucumbers, or related plants, as well as for others who cultivate the same crops on a commercial scale. The illustrations, made from original photographs by the author, may assist readers to recognize and understand the habits of the insects mentioned; the descriptions are as brief and concise as seems consistent with the importance of the subject; the remedial suggestions are generally arranged in the order of their importance, often indicating that prevention is better than a cure, or, in other words, that a little intelligent effort exerted primarily towards preventing the attack of injurious insects may result in greater benefit than an equal or greater amount of time spent in trying to destroy insects which have appeared and commenced their destructive work.

Readers will understand that the subject is arranged so as to discuss the insects in the order of their expected appearance, with relation to the development of the plants.

CUTWORMS.

Among the earliest appearing insects in gardens and fields each spring are the familiar cutworms, so designated on account of their characteristic habit of chewing off plants near or just below the surface of the ground. All forms of succulent vegetation furnish food for these ravenous pests. When cultivated plants replace the natural vegetation, on which they originally subsisted, cutworm injury often becomes serious, particularly for crops like cantaloupes, cucumbers, and others, where only a few perfect plants are required for a considerable area; for with them the destruction of a small number of plants becomes a serious matter; whereas many garden vegetables may be thinned out by cutworms, or other insects, without the loss being noticeable.

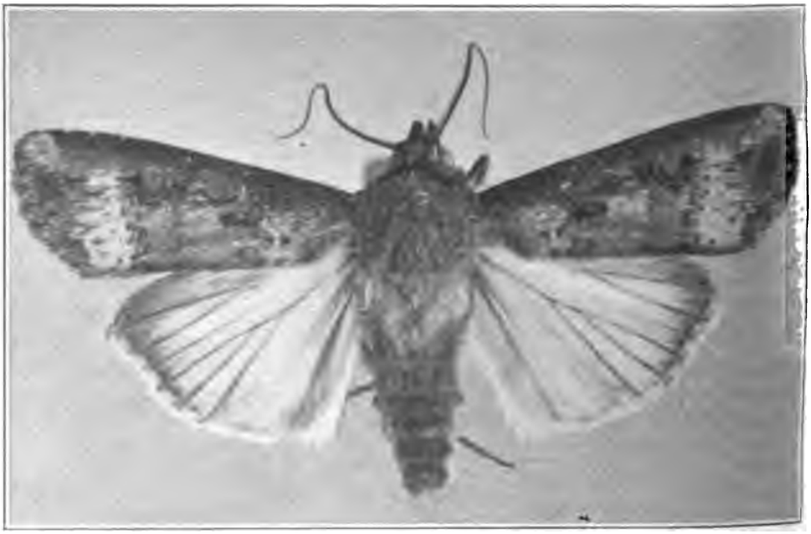


FIG. 1.—Greasy Cutworm Moth (*Agrotis ypsilon*). (Magnified 2½ times.)

Cutworms occur in all kinds of lands, but are found most abundantly in sod or neglected fields, where their presence is not noticed until the land is prepared for some cultivated crop. A study of their habits, development, winter stage and life-history serves to show when and how they may be fought most successfully.

DESCRIPTION AND HABITS.

Parent Moth.—The adult form is a night flying moth, to which a cutworm changes after having attained full growth and passed through a quiescent (pupa) stage in an earthen cell. Several distinct species of cutworm moths, differing in size, color and markings, are known to occur, but all bear a striking resemblance to each other. Collectively, they may be described as being of medium size, with hind wings lighter than the fore wings. The expanded front wings measure from one and one-half to two inches; the color of these wings is always dark brown or gray, with wavy lines of varying colors and frequently a kidney-shaped mark of a lighter color. The hind pair of wings are usually of a uniform color, but always of a lighter shade than the front ones. Fig. 1 shows a species of common occurrence.

These moths fly at night, laying eggs on the stems or among various kinds of succulent vegetation, and hide during the day, seldom moving unless disturbed, when they fly with a quick darting movement.

Eggs.—Eggs are deposited in flat masses, normally on grass and weeds, although at times on sticks or even stones. Eggs are usually laid in fields containing an abundance of vegetation, such as sod land and weedy fields where the larvæ will find suitable food. For this reason clean cultivation and the suppression of weeds tends to lessen the danger of cutworms being present.

Larvæ.—All cutworms have a smooth naked body, as compared with hairy caterpillars, varying in color from dirty green to gray or brown, often distinctly marked with longitudinal darker stripes and dots. For some of the various species, common names, such as greasy, variegated, glassy, darksided, etc., have been adopted. Cutworms are always provided with three pairs of horny legs at the anterior (head) end, and five pairs of fleshy prolegs on the abdomen to support the body when crawling. The jaws are strong and adapted for biting. The worms average about one and one-half inches in length when full grown. A very characteristic habit of theirs is, when disturbed, to curl up with the head drawn under the body. Like the parent moths, cutworms are active only at night, when they issue from their burrows in the soil to feed on any vegetation at hand, eating into the stems near the surface of the soil, severing or partly girdling them and often going from one plant to another in the course of a night. Sometimes portions of small plants are drawn down into the burrows, there to be eaten at their pleasure. During daytime the worms lie buried about an inch deep in the soil, usually close by plants on which they have fed.

Pupæ.—The full-grown cutworms prepare oval earthen cells at a depth of about two to three inches and there change to pupæ, a quiescent stage, like the silkworms in their cocoons. Finally, the pupæ change to parent moths, as already described.

LIFE-HISTORY.

The cutworms occurring in gardens and fields in early spring are in reality about one-half to two-thirds grown worms, which have hibernated in the soil, without feeding, during the winter months. Their enormous appetites and consequent ability to cause injury is therefore to be expected. Upon resuming activity in spring, and, with an abundant food supply, the cutworms increase rapidly in size, becoming fully grown by June, and then pass nearly three weeks in the pupal stage, after which the moths commence to emerge. At that season most crops are well advanced and not easily injured, hence the eggs, laid by the moths, hatch into little cutworms, whose presence and feeding are not noticeable, except in some instances. Only one generation usually occurs each year, but some species develop, during the fall months, a second generation of moths, whose progeny pass the winter in the partially grown larval stage.

PREVENTIVE AND REMEDIAL MEASURES.

With this knowledge of their habits and life-history, one should readily understand the importance of attempting to destroy the cutworms which hibernate in the soil during winter, or, failing in that, to try to poison them early in spring when the land is prepared for planting, but before the crops are above ground to serve as food. Gardens cultivated each year, if kept in good condition, free from weeds and grass, are not attractive to the egg-laying moths, while on the other hand, grassy, weedy fields and sod lands are, and they usually abound in cutworms during the fall months. It is on such lands, hastily prepared and planted during the spring rush of work. where crops may be seriously damaged. It should be remembered that the cutworms become active as soon as the earliest vegetation commences growth; hence, when land is not plowed until late in spring, the worms may feed and become quite large by the time the crop is planted. Plowing and preparing the land naturally destroys the food supply of the worms, consequently inviting their attack on whatever crop is afterwards planted.

Clean Culture and Winter Plowing.—Breaking land during late fall or winter, followed by cross-plowing or harrowing, results in disturbing many cutworms in their earthen hibernating cells. Thus exposed, large numbers succumb to the winter weather, or fall prey to fowls, birds, ants, or others of their predaceous enemies. Domestic fowls, turkeys and guineas, should be encouraged to forage over plowed fields, as they pick up large numbers of over-wintering insects. After fall plowing, seed for a cover crop may be sown to improve the land.

Poisoned Baits.—When land is properly and thoroughly prepared for planting, vegetation is practically all destroyed; hence, cutworms.

if present, deprived of their natural food supply, may then be induced to feed on poisoned baits. In small fields or gardens, poisoned baits are thoroughly practicable. To be most effective, they should be applied three or four days after land has been well prepared, thus allowing time for the cutworms to become hungry. One bait that has often proved a success is prepared as follows:

With about forty parts by weight of corn meal, or an equal bulk of bran, mix one part of Paris green or white arsenic; moisten with water to make a soft dough and then add molasses at the rate of two quarts to forty pounds of the mixture in order to sweeten it.

Another bait is prepared by cutting some succulent clover and dipping it in a half-barrel of water containing one pound of Paris green.

The freshly prepared bait should be distributed over the land about sundown, in order that it may be fresh and attractive when the worms come out at night to feed. It may be spread broadcast or dropped in little heaps at regular intervals. A second treatment two days after the first, is advisable, and should insure good results.

All poison baits should be used with caution, or not at all if domestic fowls are liable to get to it.

Mechanical Barriers.—Circular bands of stiff cardboard, tarred paper, or tin cans with the top and bottom removed, may be profitably employed to protect a few choice plants. These bands must be pressed into the soil an inch and a half deep to prevent cutworms burrowing under the edges, and should extend about two inches above the surface. Vertical holes with smooth, hard sides, made with a round iron bar or sharpened stick, near hills of cucurbit plants, are said to make good traps into which cutworms will crawl and be unable to get out again.

Repellents.—The odor of kerosene is objectionable to most insects. Sawdust saturated with kerosene and then placed around plants has been suggested to repel flea beetles and other insects attacking low growing plants, and its use may prove effective as a repellent for cutworms.

STRIPED CUCUMBER BEETLE.

(*Diabrotica vittata,* Fabr.)

Cucumber, squash and melon plants are scarcely allowed time to appear above ground in the spring before they are attacked by a small active beetle, yellow in color, with three black stripes, an insect familiar to most gardeners. Although about equally injurious to all cucurbits, this offender is generally called the striped cucumber beetle. How they always happen to be present is explained later; but for the moment let us consider the extent of the injury usually inflicted. The beetles eat the leaves, and delight especially in gnawing off the epidermis of the stems of the tender plants, and, not always content with feeding above ground, they may even burrow underneath to reach the tenderer parts. The resulting damage is slight or severe, in proportion to the number of beetles at work, but always results in retarding or entirely checking the growth. After the plants attain some size this feeding does not seriously affect further development but more or less injury of this nature continues even after plants are grown. The beetles are further charged with being the means of spreading the disease known as cucurbit wilt.

Another source of injury is caused by the larvæ (young stage) living in the soil, feeding on the tender roots of all cucurbits; also by making shallow channels in the rind of the developing fruits wherever these rest on moist soil.

Striped cucumber beetles are present almost everywhere, certainly in all the eastern States. No one should expect to raise cucurbits without reckoning with this pest. The full extent of its ravages is difficult to estimate, but delayed crops, poor stand, weakened growth and the necessity for replanting are often traceable to these beetles and their larvæ.

DESCRIPTION AND HABITS.

Beetles.—The beetles, measuring barely one-fourth inch in length, are of the shape shown in Fig. 2. The general color is yellow above, with a longitudinal black stripe toward the outer edge of each wing cover and with the inner edge of each wing black, forming a median dorsal stripe, so that the beetles show three black stripes. The head and most of the underside of the body is black.

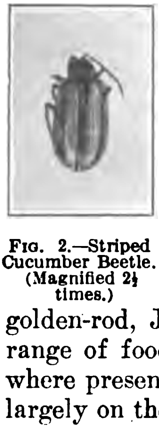


FIG. 2.—Striped Cucumber Beetle. (Magnified 2½ times.)

These beetles hibernate during winter under rubbish, stones, fences, buildings, etc., issuing forth early in spring in search of food. In this matter they are not particular, and may eat cultivated crops such as peas, beans, corn, or cucurbits, but are said to show a partiality for wild flowers like aster, sunflower, golden-rod, June berry, cherry and related plants. With this wide range of food plants it is not surprising that the beetles are everywhere present. When cucurbits commence to bloom, the beetles feed largely on the pollen.

Eggs.—The eggs were discovered in 1899, and were described as being bright lemon-yellow to orange in color, measuring about one-fortieth inch in length, and only one-half as wide. They are deposited about the roots or main stems of the host plants, or in the soil close by. One investigator observed eggs being laid on leaf stalks just below the surface of the ground. Others have seen eggs placed in crevices in the soil.

Larvæ and Pupæ.—The larvæ are slender white worms with head and anal plate dark brown. They lack the prolegs which are characteristic of the larvæ of moths and butterflies. The worms attain a length of about one-half inch, when grown, and then change to pupæ, still remaining in the soil. The pupa stage is white, while in shape and outline resembling the parent beetle, to which it eventually changes, after a period, in warm weather, of from eight to thirteen days.

LIFE-HISTORY.

The beetles emerging from winter hibernating quarters feed for a time and commence egg deposition after the host plants (cucurbits) are well above ground. Observations made by Garman[1] in 1900 indicate that egg laying does not commence in Kentucky until June, although it probably commences earlier in North Carolina. The life cycle from egg to adult may cover from one month to five weeks. The larvæ are very active, moving freely among the roots, feeding here and there, or establishing themselves under some cucumber or cantaloupe, where these rest on moist soil, and feed on the soft rind. During July and August one may easily find the larvæ in the moist soil or clinging to the rind, if cantaloupes are turned over.

Reasoning from the fact that the life cycle covers only about five weeks, one might conclude that four or five generations would occur during the summer; but, judging from investigations in other States, there must be only two or three full generations annually in the South. In New Hampshire there is only one generation, but southward from the District of Columbia there seem to be two or three. The beetles that commence egg deposition during late May or early June may continue this for two months or more; hence, the first generation may mature to adults and commence egg laying before the hibernated beetles have finished.

REMEDIAL MEASURES.

The various means adopted to prevent or lessen injury caused by the striped cucumber beetle may be classed into three more or less distinct methods: first, preventive measures; second, use of repellents; and, third, poisoning by means of dust or liquid applications. In most instances growers of cucurbits may profitably adopt one or more of the suggestions following.

Covers for Young Plants.—Knowing, as we do, that the beetles may appear as soon as cucurbits are planted, plans should be made to protect the plants during their tender age. A simple, cheap cover is made by cutting a barrel hoop in halves, crossing the two semicircles over a hill, pressing the ends into the soil, and covering the frame thus provided with gauze or mosquito netting, held in place by heaping earth around the edges. This furnishes complete protection against all insects, except cutworms, and a little poison bait may destroy them. Any frame able to support a gauze cover will answer the purpose, and may be removed entirely after about three weeks growth, if the plants are well started. These covered frames may serve for an early, and again for a later crop, besides being kept from one season to the next.

---

[1] Ky. Sta., Bul. 91.

Headley[3] recommends using a wire-screen cover made as follows: "Secure yard-wide screen wire of slightly smaller mesh than the ordinary window screen, and cut off one yard; the piece will then be one yard each way. Describe a circle on this piece, having a diameter of 36 inches, and cut off the corners. Then divide this circular piece of wire into two equal parts, fold the straight cut equally upon itself, bend the two edges over together twice and hammer them down firmly. Thus, a cone-shaped wire cover, costing a few cents and capable of withstanding several years wear, is ready for use."

These covers serve a double purpose by preventing the beetles from reaching the plants either to feed or lay eggs.

Planting Excess of Seed.—Where mechanical barriers are not employed, planting an excess of seed is advisable, although other remedial measures should not be neglected. Seed is not expensive. After the plants are well started the hills may be thinned to the desired number. Chittenden[4] has suggested planting seed in squares for each hill, planning to make a second planting one week after the first, and a third a week later, etc., if necessary. When beetles are numerous this insures getting a stand with the least possible delay.

Repellents.—Land plaster, wood ashes, tobacco dust, dry slaked lime and similar applications, sprinkled over and around young plants, are of some value, but unless used with a good insect powder or arsenical poison they are not very effective. Bordeaux mixture is probably the most valuable repellent in use, as its presence on plants is distasteful to the beetles, although here, again, some poison should be added, for it involves no more work and very little additional expense.

Kerosene has an odor distasteful to most insects. Some truckers have recently used it to saturate sawdust, sprinkling the mass over and around plants as a repellent. Just how effective this treatment will prove is as yet somewhat problematical, but the method should be given a thorough trial.

Bordeaux Mixture and Arsenicals.—Cucurbit plants may be very effectively protected from striped cucumber beetles, and other leaf-eating forms also, by spraying with a 3-4-50 formula of Bordeaux containing one-half pound of Paris green or three pounds of arsenate of lead to each fifty gallons, but it should not be applied until the vines commence to run, because it seems to check the growth of young plants. Arsenate of lead possesses a greater adhesive power than Paris green, which renders it proportionately more effective, particularly during rainy seasons. Experiments by Popenoe[5] at Diamond Springs, Va., in 1908, showed that arsenate of lead alone, or with Bordeaux, was an excellent remedy. He used only two pounds in fifty gallons, but three pounds would doubtless give better results, because the poisoning action of the arsenate is not rapid. When plants are started in hotbeds or greenhouses they may be dipped in some poison mixture before transplanting. Afterwards, as new leaves appear, the whole field may be sprayed.

---

[3] N. H. Sta., Ann. Rept. 1906-'08.

[4] U. S. Dept. Agr., Bur. Ent., Cir. 31.

The great value of this poisoning treatment depends upon the possibility of destroying the earliest appearing beetles before they commence to lay eggs for the first generation.

Dry Arsenical Mixtures.—Paris green or powdered arsenate of lead may be profitably employed if mixed with some dry powder usually recommended as a repellent. In fact, it seems like a waste of time to apply wood ashes, tobacco or lime dust without the addition of some poison. One pound of Paris green or two pounds of powdered arsenate of lead should be mixed with enough suitable carrier to make that amount of poison cover about one acre of plants. This mixture may be sifted on the plants by shaking it through a sack made of four thicknesses of mosquito netting, or any material of proper texture, or it may be applied by means of some one of the dry-powder guns that are sold for this purpose. It should be used, preferably, when the plants are moist with dew, and repeated several times during the season until the danger period is passed.

The disadvantage of a dry poison mixture compared with Bordeaux and arsenicals, is the necessity of repeating it after each rain, while the liquid spray, particularly arsenate of lead, need not be repeated oftener than necessary to protect the new growth.

Trap Plants.—A few very early cucumber or cantaloupe plants will often serve to attract the early beetles, which may then be poisoned with a strong Paris green spray. Some persons claim that gourds are especially attractive to the striped cucumber beetles, and that a few planted between the rows furnish some protection to the main crop of cucurbits. A few rows of beans are also valuable to furnish food for many beetles that would otherwise attack the main crop. Late plantings of cucurbits are advisable, to serve simply as a trap on which the beetles may be poisoned, thus reducing the number that would otherwise go into hibernating quarters.

Experiments with arsenicals and repellents have shown that the striped cucumber beetles are expert at avoiding the sprayed or dusted portions of plants, thus rendering it difficult to poison them, except during a short period after they first appear in spring and again late in the fall. For this reason it seems advisable to provide trap plants to attract the beetles, while at the same time keeping the main crop well coated with poison or repellent applications. The beetles are inclined to desert the treated plants, especially when clean plants are available, even though they might find many untouched spots on the sprayed rows.

---

[5] Va. Truck Sta., Bul. 2.

Clean Culture.—Gardens and fields where cucurbitaceous crops have been grown should be cleared of all remnants of the old plants, together with the weeds and rubbish, and this material burned, or otherwise destroyed during late fall, or, preferably, as soon as the crop becomes worthless. This reduces the chance of leaving convenient hiding places for the beetles during the winter months. Fence rows should be cleaned out and sod land adjoining the cultivated fields may be burned over to help destroy hibernating individuals.

CUCUMBER FLEA BEETLE.

(*Epitrix cucumeris*, Harr.)

A small, black, oval-shaped, jumping beetle, about one-twelfth inch in length, sometimes causes quite severe injury by eating holes in the foliage of young cucumbers and other cucurbits. The larva of this species is a leaf miner, attacking the same plants, but seldom causing much damage.

REMEDIES.

Wire screens or other mechanical covers, poison and repellent sprays, dry poison applications, clean culture, and, in fact, all methods suitable for fighting the striped cucumber beetle, are about equally effective against flea beetles.

TWELVE-SPOTTED BEETLE.

(*Diabrotica 12-punctata*, Oliv.)

(These are the parents of Southern corn root-worms.)

Among the insects commonly found feeding on young cucurbits, this characteristically marked green beetle with twelve black spots on its wing covers is nearly always represented. They feed on the foliage and in the blossoms, being present from early spring until late fall. Like the striped cucumber beetle, they enjoy a wide range of food plants, including many garden vegetables. The larval stage is the worm commonly known to farmers as the corn root-worm or corn bud-worm, which often causes very extensive injury.

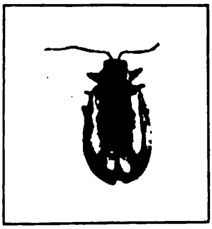


FIG. 3.—Twelve-Spotted Beetle. (Magnified 2½ times.)

DESCRIPTION AND HABITS.

Beetles.—The beetles average about three-tenths inch long; the color is green or yellowish green, with each wing cover showing six prominent black spots. Their general shape is shown in Fig. 3. They are found on all classes of plants, but especially delight in feeding upon the flowers of field crops and fruit trees, and might literally be termed omniverous and omnipresent.

Larvæ and Pupæ.—The larvæ feed at the roots of corn, wheat, rye, millet, and other cereals or grasses, but their injury to young cornfields, by which they have earned the name corn root-worm, is of first importance. The slender larvæ, which are yellowish white in color, with a brown head and strong biting jaws, attain a length of one-half inch in three to four weeks, then transform to the pupal stage in little cells in the soil, and, about two weeks later, transform again to become adult twelve-spotted beetles, as already described.

LIFE-HISTORY AND GENERATIONS.

Only two generations develop annually, but the beetles live a long time. Those of the second generation live and feed during the fall months, hibernate during winter, and appear again quite early the following spring to feed on various plants, including cucurbits such as cucumbers, cantaloupes and squash. Noticeable injury occurs only while the plants are small, although the beetles may continue feeding in cucurbit blooms during the entire season of growth.

REMEDIAL MEASURES.

The twelve-spotted beetles yield to the same treatment as the striped cucumber beetles. Where plants are protected from the latter they cannot be damaged by the former, but unless some of the remedial measures suggested on pages 9-12 are followed, the combined injury from these two forms is likely to be serious. Aside from merely protecting the cucurbit crops, all successful attempts to poison the twelve-spotted beetles result in lessening the numbers that would otherwise lay eggs around corn plants in nearby fields.

SQUASH LADY-BEETLE.

(*Epilachna borealis,* Fab.)

The above common name is applied to a large species of lady-beetle which may occur in small numbers on squash, gourds and other cucurbits. They are seldom numerous, but are mentioned mainly because their feeding habits are so strikingly different from other lady-beetles whose food consists chiefly of scale insects, plant lice, or other small insects. For this reason lady-beetles are generally considered beneficial, and should be encouraged to multiply.

The squash lady-beetles, and their larvæ also, are plant feeders, occasionally numerous enough to partially defoliate the plants on which they occur. Cucurbit growers should learn to recognize them in order to avoid making the mistake of attempting to destroy the really beneficial lady-beetles, which resemble this plant-feeding species in general shape and appearance.

DESCRIPTION AND HABITS.

Beetles.—The beetles measure about one-third inch in length, have a small head and thorax, and rather short legs. The whole body is slightly oval (Fig. 4) with a strongly arched back. The general cover is light yellow. The thorax bears four small black spots, while the wing covers when closed show twelve black spots of irregular size, two of which are divided by the inner margin of the wings, forming two large median dorsal spots. The ventral side of the body is yellow, marked with black. The legs are yellow.

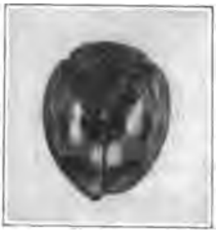


FIG. 4.—Squash Lady-beetle. (Magnified 2½ times.)

The only other native lady-beetle liable to be mistaken for this species has only nine black spots on the wing covers, while the body beneath is black, including the legs. It is also of a smaller size.

The northern lady-beetles hibernate during winter, come forth in spring and feed on the foliage of cucurbits, and at times on the rind of melons and squash.

Eggs.—The eggs are yellow in color, elliptical in shape and are laid in clusters on the underside of the leaves.

Larvæ and Pupæ.—The larvæ are a little longer than the parent beetles, yellow in color, with each segment of the body bearing six prominent branched spines, of which the basal half is yellow and terminal half black. They always feed on the underside of the leaves. When grown they transform to the pupal stage, attached to a leaf, and after a week or ten days change to adult beetles.

REMEDIAL TREATMENT.

Both larvæ and beetles are slow and stupid in action, so that removing them by hand is readily accomplished, and generally nothing further is needed than an occasional hand picking. Poison sprays, applied while the plants are small, will kill many of the beetles. As already intimated, cucurbit growers are cautioned against mistaking other lady-beetles for this species, because all other native forms may be quite beneficial by destroying melon lice and other small insects.

MELON APHIS OR PLANT LOUSE.

(*Aphis gossipii,* Glov.)

Plant lice of various sizes, colors and habits are frequently found on all forms of vegetation. Scarcely a single variety of plant or tree passes the summer without being attacked by some one or more species of these sucking insects. The melon plant louse is one of the many forms. Fields of cucumbers and melons are frequently injured by these lice clustering in enormous numbers on the lower surfaces of the leaves. The same species may occur on young cotton, and are then known as cotton lice. They are capable, when numerous, of causing severe stunting of growth or even the death of young plants. Lice may occur all through the summer months, sometimes damaging cucumbers and cantaloupes after the vines have grown to several feet in length.

FEEDING HABITS AND INJURY.

Plant lice suck the juices through a tube-like beak which is inserted into the leaf or stem. Feeding in populous colonies on the underside of the leaves, and consequently extracting the juices rapidly from that side, they cause the infested leaves to curl downward, because the upper surface contains the most moisture. The effect is similar to that resulting from wetting only one side of a sheet of paper. When hundreds or thousands of lice occur on a plant, they soon cause a stunted, weakened growth, or else death. As the leaves curl, the lice become better protected from any spray that the grower may desire to apply. Arsenical poison sprays are, of course, of no avail. Some mixture that kills by contact may be employed with good results, because the lice have soft, unprotected bodies, easily affected by mineral oils, soaps, or solutions having a caustic, penetrating action.

DESCRIPTION AND LIFE-HISTORY.

Plant lice of nearly all species reproduce by giving birth to living young, the adults being both winged and wingless. Many generations develop each season. During summer the colonies of lice contain no true males and females, representing a development known as parthenogenesis, that is, young are produced without the intervention of the male. The melon louse is no exception to this rule. True males and females are developed by the last fall generation, and, after mating, the females deposit eggs which do not hatch until the following spring. The lice hatching from these winter eggs develop into viviparous females, whose young are born alive, as already explained.

The melon louse is about one-twentieth of an inch in length and yellowish green in color. Both winged and wingless forms occur. The former serve to spread the species by flying to other plants, when the food supply becomes depleted, thus accounting for the isolated colonies that suddenly appear during the summer months. Each individual matures in from six to eight days, and is then capable of giving birth to about fifty young. Considering this rapid rate of multiplication, one would expect to see all infested plants destroyed, and such a result might, indeed, be seen were it not for the valuable assistance rendered by parasites, both internal and predaceous, which destroy great numbers of lice. With these facts in mind, let us consider the methods by which melon lice may be controlled.

REMEDIAL MEASURES.

Spraying.—Spraying infested plants with some solution that kills by contact, such as kerosene emulsion, soap solutions, or tobacco decoctions, is one method of fighting melon lice. The spray, to be effective, must hit and cover the lice on the underside of the leaves. This necessitates using a spray nozzle on the end of a curved rod, or lifting and turning the leaves and vines. Spray mixtures must be applied with a pump capable of furnishing strong pressure, so that the liquid may be forced into the colonies to touch each individual. Simply sprinkling the tops of infested plants is worse than a waste of time.

Kerosene emulsion at a strength of 10 per cent is the most effective spray in most cases. It is prepared by dissolving one-half pound of potash soap in one gallon of boiling hot water, then adding two gallons of kerosene and churning this mixture violently for ten to fifteen minutes, or until a perfectly smooth, creamy mass, without any free oil on top, is obtained. Three gallons of concentrated mixture thus prepared, diluted with seventeen gallons of water, will make twenty gallons of 10 per cent kerosene emulsion. If used at a greater concentration, or, if the emulsion is not properly prepared, some injury to plants may result. Any one making kerosene emulsion should realize that the mixture of oil, soap and water must be churned until the drops of oil become so completely broken up and combined with the soap that none will rise to the top. It is often recommended to make and keep the concentrated mixture on hand, to be diluted when used, but this practice frequently results in the use of an imperfect emulsion, which injures the plants. When freshly prepared it seldom causes injury at the strength recommended above.

Tobacco decoctions are nearly as effective as kerosene emulsion, particularly if made from fresh, strong tobacco leaves or stems.

Tobacco leaves or stems................	2 pounds.
Water	4 gallons.

Boil for about two hours.

Decoction made by the above formula should be used without dilution. By using tobacco of full strength the decoction obtained will kill practically every louse it touches, but failures often result from using too weak solutions.

Extracts of tobacco sold under various trade names are on the market and are widely advertised. The majority of them are valuable, and, as the manufacturers claim, have the advantage of being quickly prepared for use by simply diluting with cold water, and any one can soon determine the strength necessary to kill melon lice.

Soap solution, consisting of one pound of any strong potash washing soap in four or five gallons of water, applied slightly warm, is quite effective. Potash whale-oil soap is superior to common soap, and will admit of greater dilution and still be effective. A combined tobacco and whale-oil soap is prepared by some manufacturers.

Fumigation.—Within recent years a method of fumigating cantaloupe plants has been quite well perfected. Sanborn[6] made valuable experiments with specially prepared tobacco or nicotine fumigating papers, manufactured and sold under the names nico-fume tobacco paper, aphis punk and to-bac-ine, and perfected a system of fumigating by the use of cloth-covered frames. The following description of a fumigating outfit is based on his work:

Cloth-covered Frames for Fumigating.—For fumigating vines from two to four feet long construct a light wooden frame, square or rectangular, of the desired dimensions, and nail an eight-inch leg to each corner. This may be covered with heavy muslin saturated with linseed oil to render it air-tight. Cut the muslin in pieces large enough to cover the frame and extend one foot over each side, and tack to the top, but not to the legs of the wooden frame. The loose edges of the muslin may be covered with earth to prevent any escape of gas. A frame of this construction makes a perfect fumigating arrangement, as it can be placed over any portion of a long vine if desired without damage and without disturbing the vine.

The tobacco fumigating papers are so prepared as to burn rapidly, producing a dense smoke, and are used by lighting the desired amount in a tin can under one corner of the frame. Old tin cans with perforations near the bottom edge answer the purpose very well. By this method all the lice are killed in from twenty to thirty minutes, without injuring the plants. The treatment is comparatively cheap and effective—much more so, in fact, than the best spraying that could be done. By having several frames in operation, two men may fumigate large areas in a day.

Beneficial Parasites.—As already stated, parasites and predaceous enemies render valuable aid in controlling the melon lice. In Texas. Sanborn has shown that it pays to induce the increase of lady-beetles by planting rape, which usually bears cabbage lice in abundance.

---

[6] Tex. Sta., Bul. 89.

This plant furnishes food in the fall for a number of predaceous parasites, such as lady-bird beetles and their larvæ, that feed on the cabbage lice, and the beetles hibernate among the weeds and rubbish and thus are usually present in the spring and ready to attack the first broods of melon lice. Rape, as a trap plant, should be planted in summer and fall in the gardens or on the edge of the fields where cantaloupes and cucumbers are to be planted the following year.

Food Plants.—In order that readers may understand why melon lice appear in fresh lands, or fields remote from cucurbits or cotton, and why they should expect visitations of these lice each season, a list of plants on which the species has been found, as reported by Pergande of the United States Bureau of Entomology, is here given:

Shepherd's purse, pepper grass, dock, burdock, dandelion, pigweed, wormseed, plantain, chickweed, morning glory, three-seeded mercury, button weed, ground ivy, red clover, Indian strawberry, mallow, cultivated strawberry, dwarf bean, spinach, hop, cotton, pear, European dogwood, orange, hydrangea, begonía and Jamestown or Jimson weed.

As this list includes many common weeds found in cultivated fields, it serves to explain how the insects survive the winter and appear on cucurbits in all localities.

COMMON SQUASH BUG.

(*Anasa tristis,* De G.)

Stink bug is a name often applied to this insect, as well as to several closely related forms, because of their disagreeable odor.

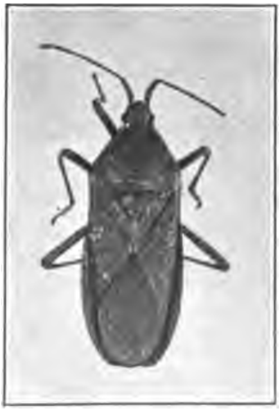


FIG. 5.—Common Squash Bug. (Magnified 2½ times.)

The squash bug is another example of a sucking insect, like the melon louse, which feed solely by extracting the plant juices. Their destructive power is, however, in one sense, much greater, for in addition to being much larger than melon lice, the wounds made by the sucking beak of the squash bugs seem to be poisonous to the plant tissue, causing the punctured leaves to wither and die as though the stem had been girdled, cutting off the food supply from the roots. For this reason a few bugs may kill young plants without actually extracting much of the sap. Fortunately, the bugs do not emerge from winter quarters until late in spring, and the early planted crops are usually well advanced when feeding commences.

Squash bugs are commonly present in gardens and fields from early June until late fall, and in addition to their destructive feeding habits they are charged with being distributing agents for the melon wilt disease, by transferring the wilt bacteria from one plant to another.

Squash and pumpkin are the favorite food plants, but other cucurbits are frequently attacked. Certain varieties of squash are injured more than others.

DESCRIPTION AND HABITS.

Adult Bugs.—Mature squash bugs measure about five-eighths of an inch in length. Their shape is shown in Fig. 5. The color is dirty brownish black above and yellowish beneath. The head bears two prominent antennæ (feelers), projecting forward, and a slender jointed beak that lies flat against the body, between the legs, when not in use. These bugs are nocturnal in habit, hiding under leaves or other shelter during the day.

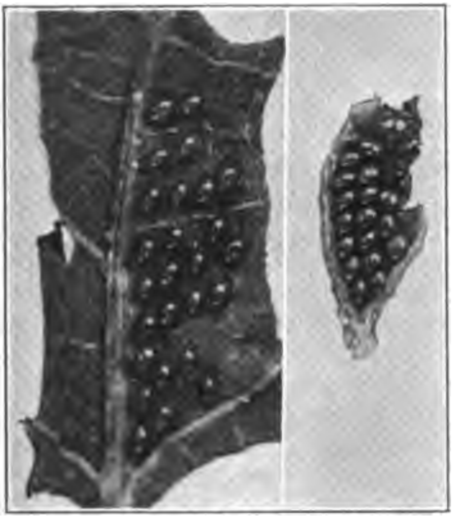


FIG. 6.—Egg Mass, Common Squash Bug. (Magnified 2½ times.)

Eggs.—These are quite large, about one-sixteenth inch long, oval in shape, bronzy-brown in color, and are laid at night in irregular rows on the underside of the leaves (Fig. 6). Egg clusters contain from a few to forty or more, frequently arranged in the angle made by two prominent veins of a leaf. Eggs hatch in from eight to thirteen days into small, awkward creatures, called nymphs.

Nymphs.—When about two days old the nymphs are green and black in color, with long legs and antennæ. At this age they feed in groups, on the underside of the leaves, where they are readily overlooked. As they increase in size the skin is molted and the body gradually changes, wing pads appear, and finally, after the fifth molt, the wings are fully grown and the bugs mature. In the meantime they separate and wander about in search of suitable food. The nymphs feed in the same manner as the adult bugs. A dozen of them may seriously injure a small squash or melon plant by the combined loss of sap and poison injected.

LIFE-HISTORY.

The winter season is passed by the mature bugs in hibernating quarters under rubbish heaps, boards, fences, or other shelter. They often wander into houses in the late fall, seeking a place to hide during winter. The survivors appear rather late the following spring, feed for a time and then lay eggs for the first generation, which is followed by successive generations until cold weather or absence of food checks further development. The generations overlap, consequently eggs, nymphs, and adults occur simultaneously during the summer months.

REMEDIAL MEASURES.

Ordinary insecticides are of little value against squash bugs. Arsenical poisons are valueless, and contact spray mixtures are effective only against the young soft-bodied nymphs. However, the bugs may be fought quite successfully by some one or more of the following methods:

Hand Picking.—The first bugs appearing in spring should be collected by hand in order to prevent egg-laying. Later on, both adults and egg masses should be gathered and destroyed, or, if the eggs have hatched, the groups of young nymphs may be easily crushed. To facilitate catching the adult bugs, shingles, large cabbage leaves, or something of the kind, may be laid around the cucurbit plants, as many will take refuge under such shelter during the daytime. Eggs and nymphs will be found on the underside of the growing leaves. Hand picking is profitable all summer if the bugs persist, but by thorough work most of the first generation may be destroyed, thus avoiding further injury.

Clean Culture.—Burning or composting remnants of cucurbit plants, together with all rubbish about gardens and fields, both after the crop is gathered and during late fall or winter, will aid materially toward preventing the adult bugs hibernating successfully. This practice is equally valuable for checking the increase of many other injurious insects.

HORNED SQUASH BUG.

(*Anasa armiger,* Say.)

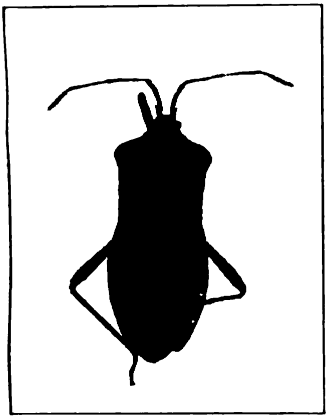


FIG. 7.—Horned Squash Bug. Adult. (Magnified 2½ times.)

In the vicinity of Raleigh the writer has found the horned squash bug nearly as common and abundant as the so-called common form. It is probable that most farmers do not distinguish between the two species, for they closely resemble each other. The horned squash bug (Fig. 7) may be distinguished by its having a shorter and wider thorax, having the terminal segment of the antennæ yellow, and by the presence of a short stout spine in front of each eye. A similar spine occurs near the tip of each femur. In habits, size, color and life-history it does not differ materially from the common squash bug.

Remedial measures, such as hand picking and cultural methods, directed against the common squash bug, will naturally include this species also.

BANDED LEAF-FOOTED PLANT BUG.

(*Leptoglossus phyllopus,* Say.)

This conspicuous plant bug has been collected and observed on cucurbits and other plants in the fields around Raleigh, and should be classed among the insects liable to become injurious in certain seasons. It is a sucking bug belonging to the same family as the squash bug, and is capable of inflicting similar injury to cucurbits. Several instances of its injury to melons have been reported. In 1898 it damaged watermelons at Seabrook, S. C., by sucking the stems close to the melons, as reported by Chittenden.[7] Quaintance[8] reported its damage in Florida, and stated that it is the cause of serious trouble, by puncturing the stems of (melon) plants and sucking their sap, causing them to wilt, and, not infrequently, bringing about their death.

This species is distributed over all the Gulf States and many of the neighboring States. In North Carolina it is quite abundant in some sections.

---

[7] U. S. Dept. Agr., Bur. Ent., Bul. 19, n. s.

[8] Fla. Sta., Bul. 34.

DESCRIPTION.

Fig. 8 shows the general shape and appearance, easily recognizable by the greatly flattened and toothed hind tibia, which has given them the name leaf-footed. They are nearly three-fourths of an inch long. A narrow light-yellow band extends across the middle of the wing covers, and a similar colored spot occurs on the inner margin of each flattened tibia. The general color is chestnut brown, except the overlapping portion of the wing covers, which appear darker. The adult bugs are active, and, when disturbed, fly quickly, with a loud buzzing noise.

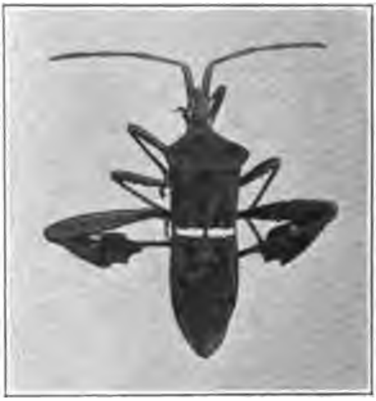


FIG. 8.—Banded Leaf-footed Plant Bug.
(Twice natural size.)

REMEDIES.

In case these bugs should become abundant, they might be controlled by hand picking during the early morning hours or about sundown, for at such times they are less active than during the heat of the day. It has been suggested that the young nymphs may be killed with kerosene emulsion.

The yellow thistle (*Carduus spinossissimus*) is their normal food plant, which suggests the advisability of keeping these plants cut down around gardens or fields where cucurbits are grown, or leaving only a few plants to serve as traps on which the bugs may be killed by spraying or hand picking.

NORTHERN LEAF-FOOTED PLANT BUG.

(*Leptoglossus oppositus,* Say.)

This species, closely related to the one already described, has been reported as damaging melons in Maryland and the District of Columbia, and occurs in many of the Southern States, including

North Carolina. The writer has found them on many different plants, corroborating previous reports of their omnivorous feeding habits.

Compared with the squash bug, this plant bug (Fig. 9) is more slender in form, chocolate brown in color, and distinguished at once by the flattened hind tibia, which, together with the wings, bear certain yellow markings.

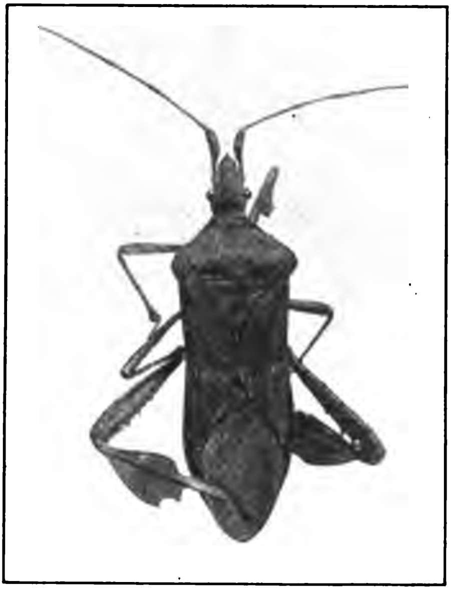


FIG. 9.—Northern Leaf-footed Plant Bug.
(Two and one-half times natural size.)

The nymphs are described as being bright red in color, with the antennæ, beak, legs and tip of the abdomen black. Erect black spines occur on the back and shorter spines are present along the edges of the abdominal segments.

SQUASH VINE BORER.

(*Melittia satyriniformis,* Hbn.)

As its name implies, this insect lives during the destructive period of its life, as a borer in the main stem or leaf stalk, but prefers to feed in the woody tissue near the root. The damage is caused by the larvæ, which are white, fleshy, grublike worms, changing eventually to moths somewhat resembling wasps.

Squash, cimblins, and pumpkins are the favorite food plants, although other cucurbits, like cucumbers and cantaloupes, are sometimes attacked. Chittenden has reported it as occurring on the wild cucumber (*Echincystis lobata*), and thinks this may be its natural food plant.

Several borers may occur in a single squash plant, and their presence remain unobserved until the whole plant suddenly withers and dies, seemingly in a single day. The reason for this sudden collapse is because the borers, feeding in the main stem, eventually girdle it completely, thereby cutting off the flow of sap from the roots to the branches, and the plant, thus suddenly deprived of food, rapidly withers under the hot July or August sun. If such plants are examined, quantities of powdered, yellowish excrement will be found around the stem, having been forced out of the feeding channels made by the borers. These dying plants usually contain several borers—a dozen or more is not an unusual number—for plants are often able to survive the presence of only three or four unless they happen to girdle the stem near the roots. Severe injury may usually be prevented by learning to recognize the first sign of borers, evidenced by the yellowish excrement around the stem, and removing them in the manner to be described later.

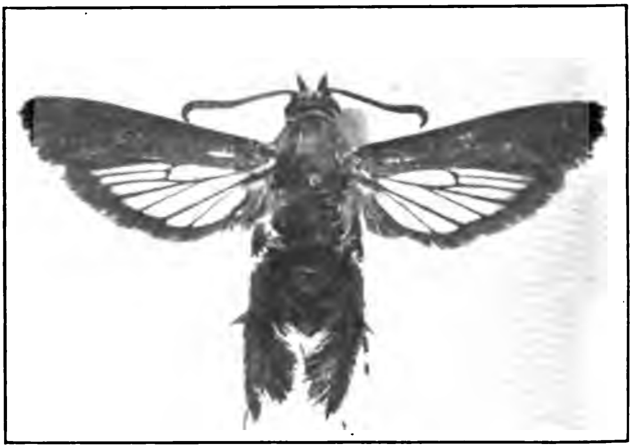


FIG. 10.—Squash Vine Borer Moth. (Magnified 2½ times.)

HISTORY AND DISTRIBUTION.

The first description of this insect was written in 1825 by Huebner, under its present scientific name. Later, in 1828, it was redescribed by Harris under the name, *Ægeris cucurbitæ,* and still later Westwood gave it the name, *Trochilium ceto;* but of recent years the name *Melittia satyriniformis* has been generally accepted. It is evident that this insect is an old offender. Its distribution now extends from Canada southward to the Gulf States, and to the West at least as far as the Rocky Mountains. It also occurs in Mexico, Central and South America, and is thought to be of tropical origin.

DESCRIPTION.

Parent Moths.—The adult or parent stage is a handsome moth belonging to a family known as clear-winged moths. The front pair of wings are opaque, olive brown in color, with metallic green reflections; the hind wings are clear and transparent, with black veins and a wide bronzy-green fringe of hairs. The hind pair of legs bear a heavy fringe of hairs, those on the outer edge orange or reddish, while the inner fringe is black. The abdomen is conspicuously orange or red, with black or bronze markings. Altogether, these moths present a striking appearance. (Fig. 10.) The males measure from an inch to an inch and a quarter across the expanded front wings; the females average a little larger, some having a wing expanse of an inch and one-half. They are readily recognized as they fly about squash plants depositing eggs during the day, and may be easily captured in a butterfly net, or knocked down with an evergreen brush or similar weapon.

Eggs.—These are dull reddish brown in color, oval, about one twenty-fifth of an inch in length, and, when magnified, show a surface composed of many five, six, or seven-sided areas. The eggs are glued to the plant and flattened on the attached side.

Larvæ.—Larvæ or borers are robust, white, grublike worms (Fig. 11), with the body distinctly segmented. Half-grown larvæ have been described as having a jet-black head, with the first segment back of the head also black; full-grown borers have a comparatively small brown head, well-developed thoracic legs, next the head, but with prolegs reduced or wanting. Average length is about one inch.

Cocoons and Pupæ.—When the borers are fully grown they desert their feeding burrows, tunnel an inch or two into the soil, and there construct cocoons in which they transform to the pupal stage.

The cocoon, composed of tough silken threads, is about three-fourths of an inch long (Figs. 11 and 12) and covered with bits of sand or earth, which adhere to the gummy secretion of the larva. This makes the cocoon resemble the soil in which it lies; but when cleaned, the silken structure is black within and without.

The pupal stage is shiny mahogany brown in color, about five-eighths of an inch long. The head bears a hornlike process, by means of which it cuts a lid in the end of the cocoon (Fig. 12) and the abdominal spines enable it to squirm out and work a passage to the surface of the soil before transforming to the adult moth.

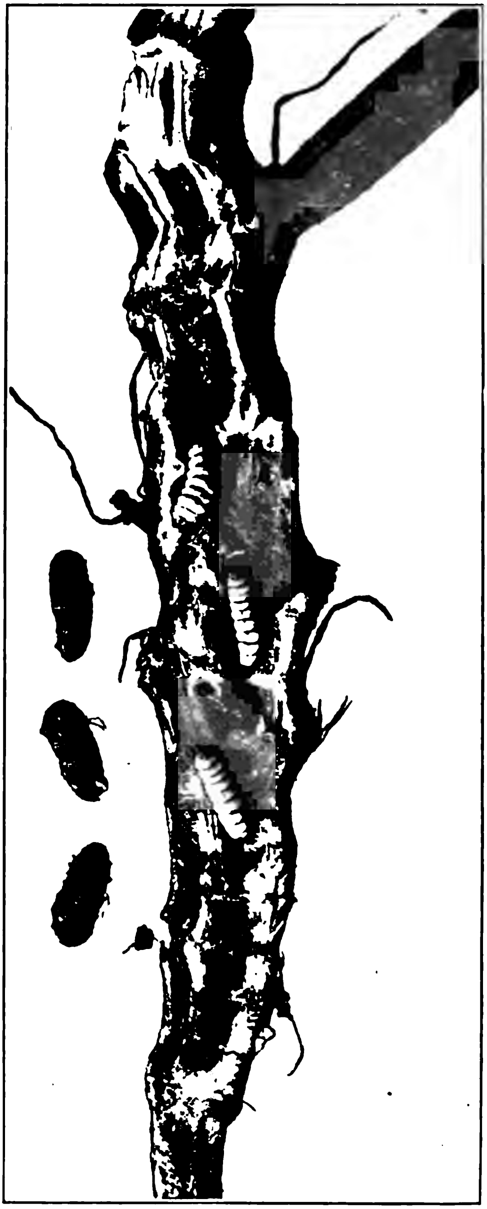


FIG. 11.—Squash Vine Borers Feeding in Squash Stem. Cocoons on left. (About ⅔ natural size.)

LIFE-HISTORY AND GENERATIONS.

Squash vine borers pass the winter in the pupal stage in the soil. Parent moths, commencing to emerge during late April or early May, soon mate and lay eggs on all parts of the plants, but chiefly on the main stems. As many as two hundred and twelve eggs may be laid by one female, according to Smith of New Jersey; but this is an unusual number. Eggs hatch in from six to fifteen days, usually nearer the former, and larvæ attain full growth in about one month. During this period they excavate long cavities in the stems, some borers working near the roots, while others locate in the base of the leaf stalks or other woody portions of the vine. Their presence is usually evidenced by the powdered, yellowish excrement forced out of the feeding-cavities.

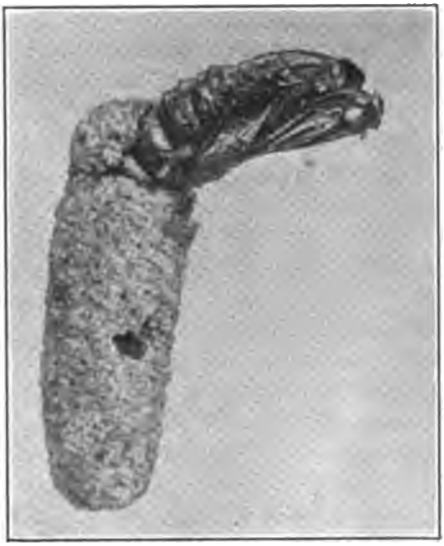


Fig. 12.—Squash Vine Borer Cocoon with Empty Pupal Shell Showing How Moth Escapes. (Magnified 2½ times.)

The cocoons are formed in the soil an inch or two below the surface, near infested plants. The pupal stage lasts from two to three weeks, or all winter, depending on the generation it represents. The writer made observations in Georgia in 1905, and found that adults of the first generation emerged the latter part of June. At Raleigh adults were reared on July 20, 1909, developing from full-grown worms collected July 2. Three days later, on the 5th, cocoons were collected underneath summer squash plants in the field; but at that date no moths had emerged. Evidently, the first generation becomes mature about the middle of July, in the vicinity of Raleigh.

The entire life cycle covers nearly two months, allowing one week for eggs to hatch, four weeks for larval development and three weeks for the pupal stage.

The second generation occurs mainly during August and September. After this the food supply is largely exhausted. Chittenden reports finding larvæ in the vicinity of Washington, D. C., during November, and states that these represent the second generation, which sometimes pass the winter as larvæ, completing their growth and transformations the following spring. The writer believes that there are only two generations, ordinarily, in North Carolina, and that the insects pass the winter in the pupal stage.

REMEDIAL MEASURES.

Cultural Methods.—Clean farming methods, such as the most successful farmers are accustomed to practice, involving the prompt removal and destruction of squash, cantaloupe and other cucurbit crops when their yielding season is past, serve in a large measure to reduce the annual injury from squash vine borers, and also other insects.

These crops are generally worthless after July or August, particularly when borers are numerous; so that, by pulling and burning, or composting infested plants, hundreds of borers in the stems or fruit may be killed.

The compost heap furnishes, in the writer's opinion, a valuable method of disposing of remnants of garden or field crops, as it produces a manure that most soils require. As a means for destroying insects like squash vine borers, melon worms and others, the compost heap may prove as effective as fire if the infested material is packed down and covered with earth, or decomposed compost, in order that the heat generated in the pile may destroy the larvæ and pupæ or imprison the adults which sometimes emerge from their cocoons a few days after the material is piled. Many moths may mature and escape from cucurbit plants which are gathered and dumped loosely in a pile. It is safest to burn this material and thus lose most of its fertilizing value, unless it is worked into compost as suggested. Diseased vines should always be burned.

Late fall and early winter plowing serves to bury over-wintering pupæ so deep that the emerging moths cannot escape, or exposes the pupæ so that some die from unfavorable weather conditions and others fall prey to birds and fowls. One objection often raised to fall plowing is that land should not remain bare all winter; but that condition may be avoided by sowing some cover crop like crimson clover, vetch, winter rye, or winter oats, which puts the land in better condition than it would be otherwise.

Deep spring plowing of gardens or fields where cucurbits have grown is advisable, when such land has been left untouched all winter. This serves to bury the pupæ so deep that they cannot work their way to the surface. Shallow plowing, only three or four inches deep, does not answer this purpose.

Rotation of crops is of some value. It is not advisable to plant cucurbits on land that has borne infested plants during the preceding season.

Remove Borers.—Squash vine borers may be detected by the accumulations of yellowish excrement on or around the stems of infested plants. During June this is often quite noticeable, and, when detected, the borers should be searched for and removed. The stems may be cut and split longitudinally without much injury, and after the borers are removed the wounds may be covered with earth to facilitate healing. Every borer removed and killed before the last of June means one moth less to lay eggs for the more destructive second generation.

Killing the Moths.—Since the moths are active during the daytime and quite readily recognized, it is profitable to capture them in nets, or knock them down as they fly about busily engaged in depositing eggs.

MELON WORMS.

Annual injury to cantaloupes, cucumbers, squash, and other cucurbits to some extent, is caused by worms that bore holes in the young or maturing fruit, feed on the buds, blooms and foliage, and even burrow in the vines when blooms and fruit become scarce. Such damage throughout North Carolina is caused by two species, one generally known as the pickle worm and the other called the melon worm. They differ in appearance and habits, but in many respects their work is so much the same that farmers do not, as a rule, distinguish one from the other. During some seasons the pickle worms may be more abundant than the melon worms, or *vice versa.* At any rate, it seems best to mention them separately.

PICKLE WORM.

(*Margaronia nitidalis,* Cramer.)

Other names, such as cantaloupe worm and melon worm, may be equally appropriate: but since the term pickle worm was first used for this species, the writer will consider it as such. Besides, the term melon worm is now applied to a closely related form.

DESCRIPTION AND HABITS.

Parent Moths.—The parent of the pickle worm is a night-flying moth of rather distinctive appearance (Fig. 13). The general color, viewed from above, is yellowish brown. The front wings bear a yellowish, semi-hyaline spot near the center, and the hind wings have the inner two-thirds of the same appearance. The abdomen terminates in a large movable brush composed of numerous elongated scales. Quaintance[9] states that the brush of the female moth is smaller and the individual scales flatter and more curved than in the male. In size the moths have a wing expanse of a little over one inch, while the body averages about five-eighths of an inch from the tip of the head to the end of the brush. The shy, retiring habits of these moths prevent their being often observed, for they seldom fly in the daytime, unless disturbed, and then quickly attempt to hide. In this respect they differ from the melon worm moths, which are often seen flying about cucurbit fields during August or September.

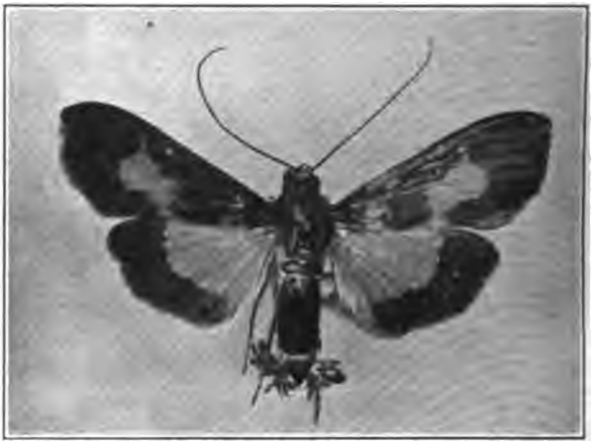


FIG. 13.—Pickle Worm Moth. (Magnified 2¼ times.)

Eggs.—Freshly laid eggs are white, but soon turn yellowish, as the larvæ inside develop. They may be laid singly, but more commonly in clusters of from three to eight, on bloom buds, leaf stalks, or leaves, and are usually attached to the plant hairs in such a manner that the egg mass seems to be pierced by the hair. The eggs hatch in warm weather in about four days.

Larvæ.—Very young larvæ are uniformly yellowish white, but after a few days the body segments show transverse rows of brown spots, which become more prominent and nearly black in color before the fourth molt is passed (Fig. 14). Larvæ molt four times before attaining full growth, and their distinctive marking, previous to the fourth molt, enables one to separate them readily from the related species called the melon worm. After the fourth molt pickle worms become greatly changed in appearance by practically losing the transverse blackish spots. Full-grown worms are yellowish or greenish in color, depending somewhat on the food supply. Just before pupating many worms assume a dull copper color above, although some do not change. Their length depends entirely on whether they are crawling, resting or contracted, as when disturbed; hence, this measurement may vary from five-eighths to one inch and a quarter. Pickle worms feed in bud clusters, blooms or fruit and often in the vines, but seldom feed, like melon worms, on the foliage.

---

[9] Ga. Sta., Bul. 45.

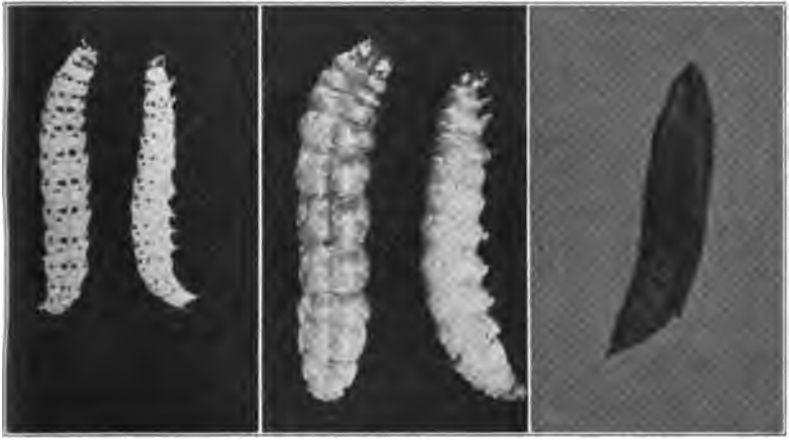


FIG. 14.—Pickle Worms and Pupa. Two worms on left, as they appear before fourth molt; in center, worms nearly ready to pupate; pupa on right. (Magnified 2½ times.)

Pupæ and Cocoons.—Pupæ are nearly three-fourths of an inch long and are of a shiny brown color (Fig. 14). The head end is rather blunt, while the caudal end is sharply pointed and bears a group of curled spines that serve to hold the pupæ in their cocoons.

The cocoon is a thin, scanty covering of white silken threads, spun by the worm in a fold of some leaf before transforming to the pupal stage. They are generally found in dead or dying leaves near the ground, or lying on the soil under the infested plants.

LIFE-HISTORY.

Winter Stage.—Pickle worms pass the winter in the pupal stage, above ground, and unprotected, except for the thin cocoon and its enveloping leaf, as already described, or such vegetation as happens to fall over and around them. For this reason the practice of raking up and burning or composting remnants of infested crops, followed by deep plowing, is of value.

Earliest Appearance.—Fortunately for cucurbit growers, pickle worm moths do not emerge from the over-wintering pupæ until late spring or early summer, thus allowing time for an early crop to mature before the worms become troublesome. Around Raleigh, in 1909, the first generation of worms matured about July 30, showing that the moths which laid eggs must have been present in June. In eastern North Carolina, where pickle worm injury commences earlier than it does here, the moths must appear the latter part of May. It is thought that rainy springs bring them out earlier.

Life Cycle.—The average time required for the full development of a generation in the vicinity of Raleigh was determined by the writer, in 1909, as twenty-seven to twenty-eight days. This record was obtained during August and September. Eggs require about four days to hatch, larvæ take about fifteen days to mature, and the pupæ transform to moths after eight or nine days. This represents the normal rate of development for warm weather, but during October and November, under the influence of cooler weather and scarcity of food, the growth is retarded.

Generations.—During favorable seasons four or five generations may develop, provided the moths appear early in the summer; but it is doubtful if more than four full generations occur normally. This point could not be accurately ascertained by the writer last season, and has not as yet been determined by any investigator.

REMEDIAL MEASURES.

Early plantings of cantaloupes and cucumbers may escape injury from this pest, owing to the late appearance of the moths, as already explained. Little complaint is heard from growers who raise early crops for market, but when the harvest comes during July and August serious damage may be expected. No absolute remedy is known; still, a large proportion of the annual loss may be prevented by the use of squash as a trap plant, clean culture and deep plowing, and possibly by poisons.

Trap Plants.—Pickle worms evince a decided preference for the buds, blooms and fruit of summer squash. The egg-laying moths are evidently attracted by the large plants and blooms, which afford abundant food for the worms. A single squash bloom may be inhabited by two or three large pickle worms (Fig. 15), or a greater number of young ones, and several may mature in a small squash. Their partiality to squash blooms was observed in Georgia during 1898 by Quaintance,[10] who at that time strongly recommended squash as a trap plant, and later published records of a field experiment showing that an acre of cantaloupes were almost completely protected by a few rows of summer squash. During the summer of 1909 the writer had an opportunity to verify Quaintance's recommendation, and he now believes that this practice is more valuable than any other single remedial measure.

---

[10] Ga. Sta., Buls. 45 and 54.

To secure the best results, seed should be planted two or three times at intervals of about three weeks, making the first planting in time to insure having the squash plants blooming freely by the middle or latter part of June. They must then be examined frequently, and, when worms are discovered, infested blooms and fruit should be gathered and destroyed at least once a week to prevent the larvæ from maturing, thus reducing the numbers of the second generation, while protecting the main crop in the meantime. Failure to collect the worms results in an increase of the second and third generations; but in case no attempt is made to gather them their presence on the squash plants shows that the main crop of cantaloupes or cucumbers is being protected.

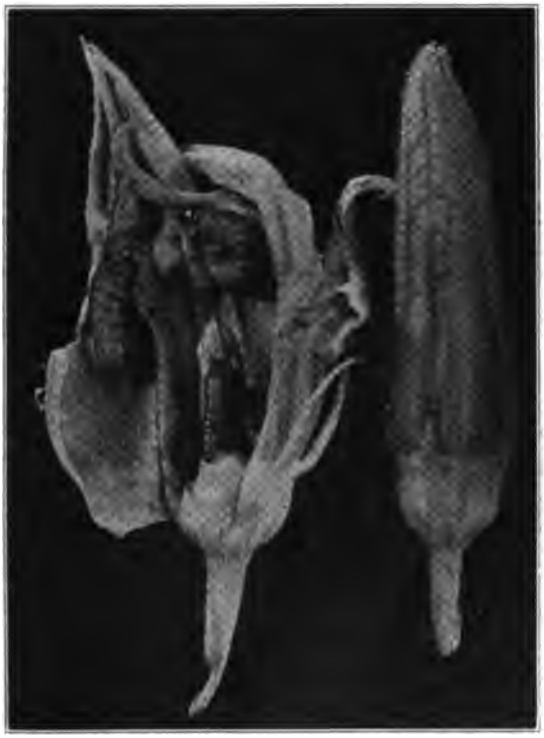


FIG. 15.—Showing How Pickle Worms Feed in Squash Bloom.
(Natural size.)

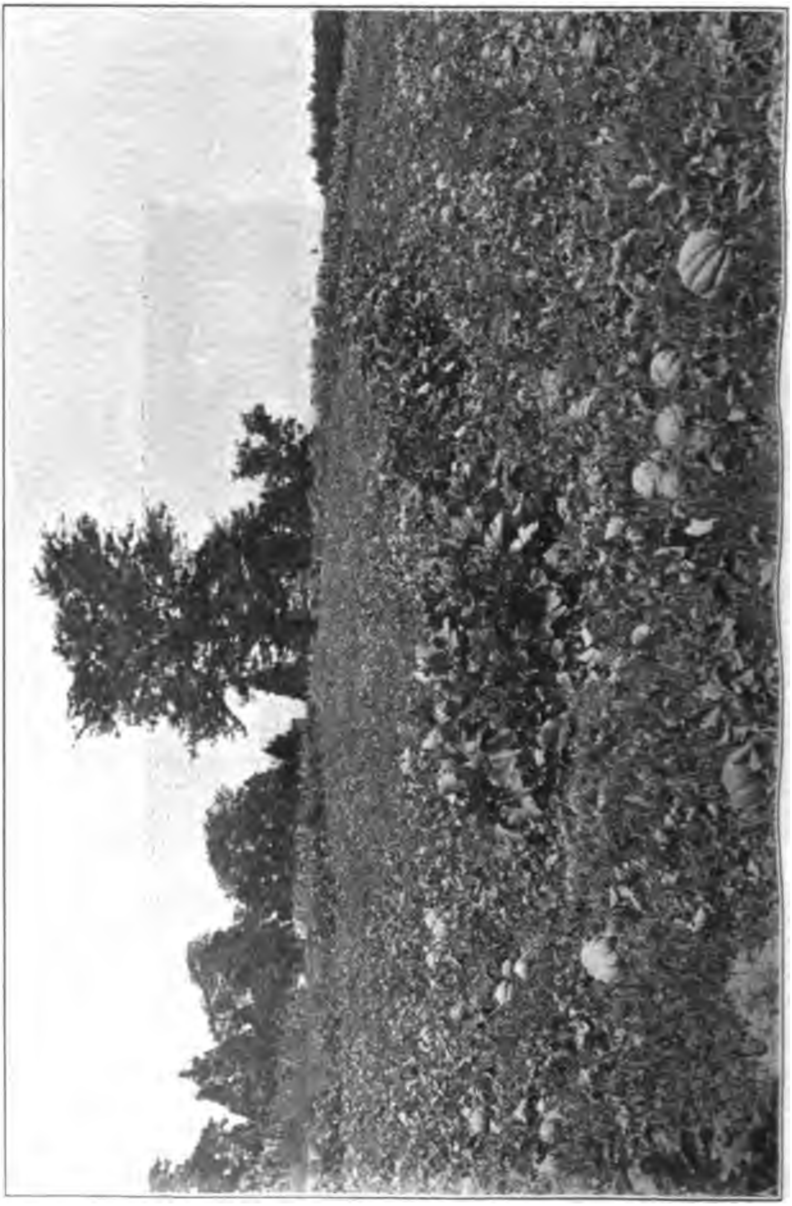


Fig. 16. Row of Summer Squash in Cantaloupe Field, Acting as a Trap for Pickle Worms.

Some readers may believe that squash and cantaloupes or cucumbers will cross-pollinate, thus rendering the latter of poor quality; but this is seldom true, although seed for the following year should not be used from any crop grown under such conditions.

Destroying Infested Plants and Fruit.—All infested fruit should be gathered and fed to hogs or otherwise destroyed to kill the larvæ within. If thrown aside, as is frequently done, the worms contained therein may mature and change to moths. If trap plants become very badly infested they should be pulled up and destroyed by composting; and the same is true of the main crops.

As soon as a cucurbit crop is matured and gathered, rake up and destroy the vines, together with all weeds and trash, to kill the larvæ and pupæ that may be present. The compost heap referred to on page 28 is strongly advocated, except when the plants have been attacked by some fungus disease, in which case burning would be better.

Deep Plowing and Rotation.—Turning the land by deep plowing immediately after a crop is gathered, or else in late fall, or even in spring, will serve to bury some of the pickle worm pupæ which are left on the land and would otherwise transform to moths.

It is not advisable to plant cucurbits on land which has borne infested plants the previous season, although the pickle worm moths fly for considerable distances, rendering rotation by no means a certain preventive measure.

Poisons.—Poisons are mentioned last, because, in the writer's opinion, they are of little value against pickle worms. Poison dusts or sprays applied to trap plants, or even the main crop, may serve to catch some young larvæ that feed on the leaf buds or unopened blooms, especially when plants are badly infested; but the practice cannot be recommended, except when melon worms are present. The latter may be poisoned because of their habit of feeding on the foliage, as explained in the following pages.

MELON WORM.

(*Diaphania hyalinata,* Linn.)

During the season of 1909 melon worms were present, in the vicinity of Raleigh, in numbers nearly equaling the pickle worms, but appeared too late to injure cantaloupes that matured before the middle of July. During September and October they were abundant in late squash and cucumbers. Concerning the usual number of melon worms, the writer has no data to serve for comparison with the pickle worm injury; but from personal observation during the past two summers, he believes that the former are of least importance. However, all truckers and farmers should know and understand the habits of both species. Melon worms are considered to be a more strictly Southern form, and they certainly occur in greater numbers in Florida and Georgia than in North Carolina.

DESCRIPTION AND HABITS.

Parent Moths.—Melon worm moths are beautiful creatures, which may often be seen flying about cucurbit fields during the late fall months. They have wings of a pearly white color, bordered with brownish black (Fig. 17). The abdomen is also pearly white, tinged with brown at the caudal end, which terminates in a large movable brush of elongated yellow and dark-brown scales. Nearly all the underside of the body, including the legs, is of the same color as the wings. The wings expand one inch, or a little more. The moths, although shy and rapid fliers, are frequently seen during the daytime.

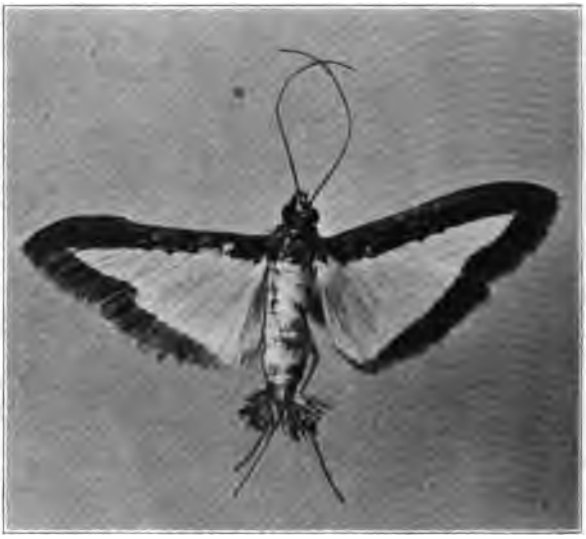
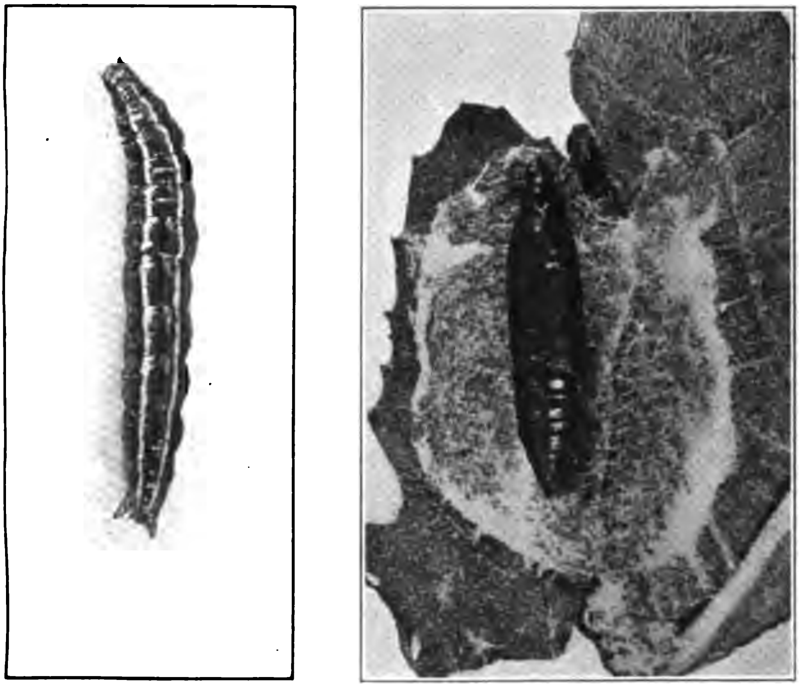


FIG. 17.—Melon Worm Moth. (Magnified 2¼ times.)

Eggs.—These are pearly white in color, very small in size, and are laid in groups of from two to six or more on the stems, leaves and buds, but are seldom attached to the plant hairs, like the eggs of the pickle worm moths. The eggs vary in shape by being crowded against each other, usually overlapping. They hatch in about four days in warm weather.

Larvæ.—Just hatched larvæ are about a twenty-fifth of an inch long, with a pale brown head, and body of a pale yellow color, with no distinct markings. At about three days of age the skin is molted for the first time, and then the body shows two faint longitudinal sub-dorsal white stripes, which become more prominent as the larvæ develop. By these two white stripes melon worms (Fig. 18) may be readily distinguished from the pickle worms until they are nearly grown. After the fourth molt, but not until two or three days before the worms transform to pupæ, these white stripes nearly disappear, after which melon worms do not differ much from full-grown pickle worms, except in possessing finer, shorter hairs and usually a more slender body. Full-grown melon worms may measure an inch and a quarter when crawling.



a. b.

FIG. 18.—*a*, Melon Worm Photographed Alive on Piece of Cimblin; *b*, Pupa Exposed on Squash Leaf. Notice the Thin Silken Web or Cocoon. (Magnified 2½ times.)

These worms often feed for their entire lifetime on the foliage, remaining on the underside partially concealed by thin silken webs. They also feed in the terminal bud clusters, and bore into melons and squash like the pickle worms. The habit of feeding on the foliage makes it profitable to use poison sprays as a remedy, and in this respect they are more easily controlled than pickle worms.

Cocoons and Pupæ.—Melon worms spin thin silken cocoons in the folded edge of some leaf, like the pickle worms, but differ from the latter in being inclined to select a green leaf rather than a dying one. When the food plants are nearly defoliated the worms crawl to nearby weeds or grass, and there spin cocoons and pupate.

The pupæ are about three-fourths of an inch long and brown in color (Fig. 18). Compared with the pickle worm pupæ, they are rather more slender and have a more sharply pointed head.

LIFE-HISTORY.

Winter Stage.—The winter is passed in the pupal stage like the pickle worms, and under practically the same conditions. Some people think that the moths emerging very late in the fall may live over-winter, but the writer doubts if this ever occurs in North Carolina.

Earliest Appearance.—Moths do not emerge from over-wintering pupæ until June or July. Around Raleigh, in 1909, they were not observed in the fields until about August first, although a few must have been present fully a month earlier, because nearly mature worms were discovered on August 5th. Rainy seasons bring the moths out early, comparatively; but, ordinarily, they are not seen before the latter part of June, which is rather later than the first appearance of pickle worm moths.

Life Cycle.—The average life cycle from egg to adult, as determined by the writer during August and September, 1909, was practically twenty-eight days. It was found that eggs hatch in four days, and larvæ mature in about sixteen days, while the pupal stage lasts an average of only eight days. Thus it appears that pickle worms and melon worms develop in practically the same time.

Generations.—No accurate record is available concerning the number of generations, although there must be four each season when the moths appear as early as June; but during some seasons, particularly in the northern and western sections of the State, the fourth generation may not occur. Fortunately for truck growers, a crop of early cantaloupes, squash or cucumbers may ordinarily be grown before the worms become troublesome.

REMEDIAL MEASURES.

Because of feeding freely on the foliage, melon worms may be poisoned with arsenical sprays, and the additional methods suggested for controlling pickle worms are equally applicable to this species, with the exception of squash blooms as a trap. Melon worms do not prefer squash blooms, although sometimes found feeding in such situations; but they do undoubtedly love to feed on squash foliage and fruit, so that when this plant is used as suggested on page 32, to trap the pickle worms, spraying with some arsenical mixture, such as three pounds of arsenate of lead or one-half pound of Paris green in fifty gallons of water, applied especially to the underside of the leaves, will serve to poison melon worms which are present. The trap plants are thus made to serve a double purpose.

Supplementing the poisoning method, the complete removal and destruction of badly infested trap plants, badly infested fruit of all cucurbits, and remnants of infested crops, together with the practice of deep plowing and rotation, should suffice to prevent serious damage from melon worms.

INDEX.

PAGE.

Aphis, the melon.......... 15
Arsenate of lead, uses of..........11, 38
Arsenical poison sprays—
  for striped cucumber beetle..........10, 11
  for twelve-spotted beetle.......... 13
  for squash lady-beetle.......... 14
  for melon worms..........35, 38
Arsenical dust mixtures—
  for striped cucumber beetle.......... 11
  for twelve-spotted beetle.......... 13
  for cucumber flea beetle.......... 12
Bordeaux mixture, with arsenicals, as a repellent.......... 10
Compost heap, value of.......... 28
Covers to protect young cucurbits.......... 9
Cucumber flea beetle.......... 12
Cutworms (*illustrated*) 4-7
  description and habits of.......... 5
  life-history of 6
  remedial measures 6
Fumigation, to kill melon aphis.......... 17
Horned squash bug.......... 21
Kerosene emulsion, preparation and use of.......... 16
Lice (see melon aphis).......... 15
Leaf-footed plant bug, the banded (*illustrated*).......... 21
  description and remedial measures.......... 22
Leaf-footed plant bug, the Northern (*illustrated*) 22
Melon aphis 15-18
  feeding habits and injury.......... 15
  description and life-history of.......... 15
  remedial measures 16
  food plants of.......... 18
Melon worms (two species) (*illustrated*)..........29-38
Melon worm (striped) (*illustrated*)..........35-38
  description and habits of.......... 36
  life-history of 38
  remedial measures 38
Northern leaf-footed plant bug (*illustrated*).......... 22
Parasites, controlling melon aphis.......... 17
Poison baits for cutworms.......... 6
Pickle worms (*illustrated*)..........29-35
  description and habits of.......... 29
  life-history of 31
  remedial measures 32
Rotation of crops, value of.......... 35
Soap solution, uses of.......... 17

PAGE.
Squash bug, the common (*illustrated*) ... 18-20
  description and habits of ... 19
  life-history of ... 20
  remedial measures ... 20
Squash bug, horned (*illustrated*) ... 21
Squash lady-beetle (*illustrated*) ... 13
  description of, and remedial measures ... 14
Squash vine borer (*illustrated*) ... 23-29
  history and distribution of ... 24
  description of ... 25
  life-history of ... 27
  remedial measures ... 28
Striped cucumber beetle (*illustrated*) ... 7-12
  description and habits of ... 8
  remedial measures ... 9
Tobacco decoction, uses of ... 16
Tobacco fumigating papers, uses of ... 17
Trap plants, uses of ... 11, 17, 32
Twelve-spotted beetle (*illustrated*) ... 12
  description and habits of ... 13
  remedial measures ... 13

BULLETIN 206 .MARCH, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

INSECTS AND FUNGOUS DISEASES OF APPLE AND PEAR

Edwards & Broughton Printing Co.
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

Governor W. W. Kitchin, *ex officio* Chairman, Raleigh

C. W. Gold	Raleigh	M. B. Stickley	Concord
E M. Koonce	Jacksonville	T. T. Ballenger	Tryon
T. W. Blount	Roper	N. B. Broughton	Raleigh
D. A. Tompkins	Charlotte	O. L. Clark	Clarkton
J. T. Ellington	Smithfield	Everett Thompson	Elizabeth City
W. E. Daniel	Weldon	R. H. Ricks	Rocky Mount
W. H. Ragan	High Point	O. Max Gardner	Shelby
W. B. Cooper	Wilmington	Locke Craig	Asheville

STATION STAFF

D. H. Hill, President of the College

C. B. Williams	Director and Agronomist
W. A. Withers	Chemist
F. L. Stevens	Vegetable Pathologist and Bacteriologist
J. S. Jeffrey	Poultryman
F. C. Reimer	Horticulturist
R. S. Curtis	Animal Husbandman
John Michels	Dairy Husbandman
R. I. Smith	Entomologist
G. A. Roberts	Veterinarian
J. G. Hall	Assistant in Plant Diseases
W. C. Etheridge	Assistant Agronomist
B. J. Ray	Assistant Chemist
A. R. Russell	Assistant in Field Experiments
P. L. Gainey	Assistant Bacteriologist
L. R. Detjen	Assistant Horticulturist
F. W. Sherwood	Assistant Chemist
A. F. Bowen	Bursar
C. P. Franklin	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

INSECTS AND FUNGOUS DISEASES OF APPLE AND PEAR.

By R. I. Smith, Entomologist and F. L. Stevens, Pathologist.

The apple orchard industry in North Carolina is increasing yearly, and will continue to advance if those who are now engaged in the business place good fruit on the market. Already there are about one million apple trees in the State, but there is room for many times that number. The problem of securing land and location suitable to the growth of apples, is of course the first consideration, if profitable crops are to be secured, but of equally great importance is the matter of controlling the injurious insect pests and fungous diseases, which will undoubtedly appear soon after the trees are planted. An annual loss of from ten to fifty per cent, or more, in the value of the crop or the condition of the trees, is caused by insect pests and fungous diseases, where trees are not protected by spraying or some other tested preventive measure, when with proper treatment the loss of fruit or trees may be reduced to a small percent.

When a comparison is made between the wormy, scabby, disfigured, or rotting fruit so often offered for sale, and the beautiful specimens free from worms and blemishes which are seen in the best markets where they command a high price, the difference in price alone indicates which ones are profitable. The purchaser does not usually realize how many enemies there are from which the fruit grower must protect his apples or pears while growing, but the purchaser can and does appreciate good, sound, healthy fruit, and is willing to pay a good price for it.

The successful fruit grower should study and become acquainted with the orchard pests, which are discussed in this bulletin. After becoming familiar with the different forms, in connection with their life history and habits, a more intimate knowledge will come easily through experience and careful observation.

Among the insect pests, the most common and destructive forms are: the scale insects which occur on the limbs; the borers in the roots, trunk or limbs; the sucking plant lice on the roots or foliage; and the worms in the fruit. In addition to these the work of leaf-eating caterpillars and curculio should be mentioned.

Fungous diseases, such as scab, ripe rot, rust, leaf spot, hypochnose and black rot are, one and all, to be expected to injure the fruit or even to totally destroy it. Blight which is caused by a bacteria always commands a portion of the attention of the fruit grower.

These statements about orchard pests should not alarm any person who is thinking of planting an orchard, for even though all the common pests and others also, have to be fought annually, there is good profit in apple or pear raising for the grower who will take proper care of the trees. The insects and diseases render constant attention and intelligent management necessary for profitable fruit growing. They afford opportunity for the intelligent, well-informed. vigilant orchardist to produce a crop of high market value, while they destroy the crops of the careless and ignorant.

In acquiring a knowledge of the more destructive orchard pests, with reference to cause, effect and remedial measures, the fruit grower will learn how to manage and prevent more than one trouble at a time. For instance, the spraying of apple trees with lime-sulphur wash in winter is a means of killing the San Jose scale, and also serves to kill the spores of fungous diseases which are living over winter on the bark, and also helps to control some insects besides the scale. Spraying in spring, just after the blossoms fall, with Bordeaux mixture and an arsenical poison serves to lessen the amount of wormy fruit as well as the scab, rust and other fruit and leaf diseases. Spraying in the summer to prevent apple rot and scab, serves also to cover the foliage with poison and thus kill caterpillars and other insects that eat the leaves.

There are many reasons, therefore, why a fruit grower should study all the principal orchard pests, rather than simply to learn how the San Jose scale, or apple worm, or apple scab, may be controlled. He should know how much real benefit results from careful spraying and other preventive measures. It is usually greater than most people suppose, and may mean all the difference between good profit and total loss.

I.—INSECT ENEMIES.

By R. I. Smith.

APPLE WOOLLY APHIS.

(*Schizoneura lanigera,* Hauss.)

The apple woolly aphids occur in damaging numbers principally on the roots, and are really responsible for the stunted, unhealthy growth, or even the death of hundreds of apple trees each year. In spite of this their presence often remains unnoticed except by orchardists who give strict attention to the condition of their trees. The extent of the damage must be far greater than is commonly supposed, when the number of infested trees in nursery blocks, together with those in both young and older orchards, is considered. In short, the woolly aphis is one of the most serious of apple pests, ranking with the San Jose scale and the apple worm.

ORIGIN AND DISTRIBUTION.

The original home of the woolly aphis is not definitely known, but they now occur throughout the world. In Europe the insects are known as the American blight on account of their supposed introduction on nursery stock from America. In the former country they are not a serious enemy to the roots of apple trees, but cause galls on the limbs and branches, sometimes so extensive as to kill trees, while in North Carolina and other southern states their injury to the roots of apple trees is of greatest importance. In the Northern States the aerial form, occurring on the branches, is more serious than the root form.

GENERAL DESCRIPTION AND INJURY.

The apple woolly aphis belongs to a family of insects including all the so-called plant lice which infest the buds and leaves of trees and plants during the summer months (for a description of the apple leaf aphis see page 65), but differ from most species in appearance, by secreting from their bodies a white, cottony substance, and they occur principally on the roots of apple trees. There is an aerial form of the woolly aphis which lives during late summer or fall on the trunk, limbs or branches, feeding usually in wounds made by pruning and in cracks and bruised places on the bark. Nearly all apple growers have seen these cottony masses, sometimes very small, but often extending a few inches along a crack, or wound caused by pruning off a limb. These masses, when examined, are found to contain numbers of brownish insects of various sizes, but none larger than a pin-head. The effect on the plant tissue takes the form of irregular galls which eventually become dead and dry, and, when

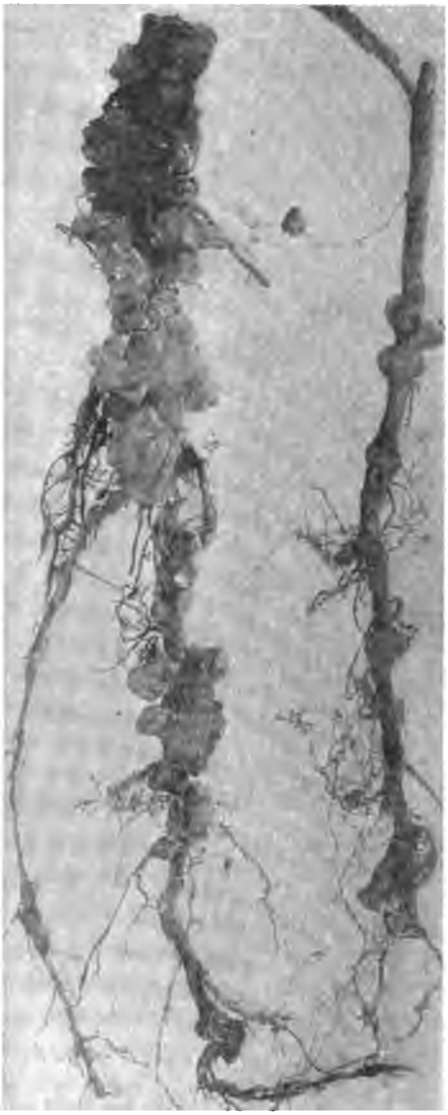


Fig. 1.—Woolly aphis galls on apple roots; specimens taken from a ten-year old tree. (About one-half natural size.)

this occurs, the insects migrate to other wounds or extend over a wider area.

Of much greater importance than the aerial form, there is the root inhabiting form of woolly aphis, which, by their feeding, cause abnormal swellings or galls, appearing like the illustration on page 46. The cottony secretion of the insects living on the roots is not always as white as it appears on the branches, although this covering is always present to a greater or less extent.

OUTWARD APPEARANCE OF INFESTED TREES.

The presence of woolly aphids on the roots may often be detected from the outward appearance of the trees. If badly infested they usually present a sickly appearance, indicated by the scanty foliage of a yellowish color and often a dwarfed growth. After the aphids have been present for two or three years the roots become so badly weakened that the entire tree may be easily loosened and pushed over; in fact, they are sometimes blown down by a high wind.

The colonies of the aerial form, on the branches during summer, or the galled areas where the aphids have occurred, are easily detected, and may be taken as evidence that the roots are infested.

FEEDING HABITS AND FORMATION OF GALLS.

Similar to all plant lice the woolly aphids subsist on the plant juices, feeding by means of piercing and sucking beaks. Wherever they feed galls of greater or less size are produced, the exact reason for which is not fully understood. It is due probably to some poison injected by the insects into the tissue of the plants.

The galls formed on the soft root tissue are large abnormal growths which soon commence to decay, their destruction being hastened by the entrance of fungi and bacteria. As the roots weaken and die the aphids die also, or move to other roots, so that when looking the first time, for signs of the woolly aphis, one may find badly injured roots from which the insects have all disappeared. By further search live aphids may usually be discovered on the few live roots remaining, or on close-by trees. The continual weakening and rotting of infested roots is what renders woolly aphis damage so disastrous. This drain on the vitality of the trees soon results in the characteristic, sickly (Fig. 2), dwarfed appearance as already explained.

DESCRIPTION OF INSECTS.

The form occurring on the roots—frequently called the apple root lice—and the aerial form, do not differ much in appearance. In reality they are of the same species.

The individual insects are reddish brown in color, but vary in size, depending on their age. The young are very small. Full grown

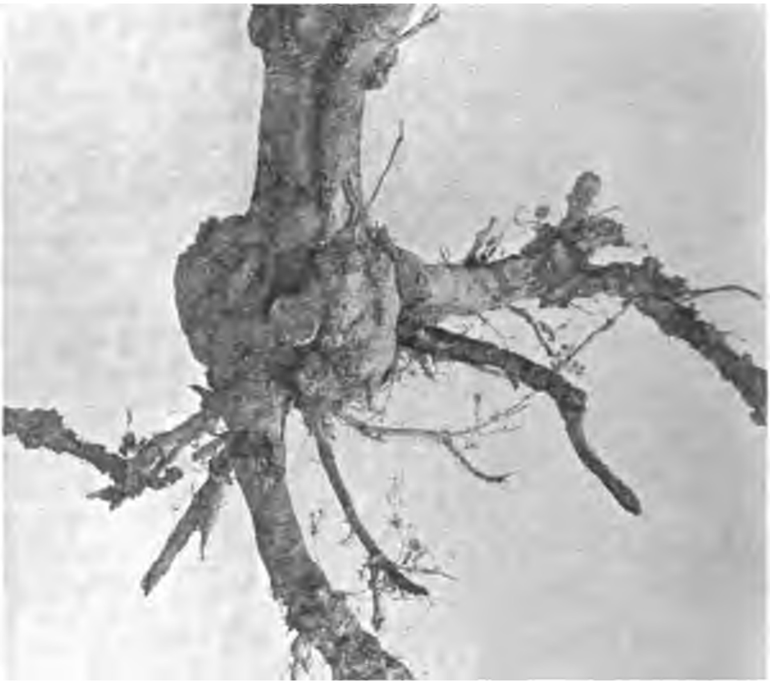


FIG. 2.—Woolly aphis injury to crown and roots of apple tree. Enlarged crown may be partially crown-gall. Original tree was twelve years old, only about eight feet high, showing stunted growth due to woolly aphis.

aphids are about one-tenth inch in length. A good idea of their appearance may be obtained by breaking through the cottony covering of a colony above ground and examining the aphids with a magnifying glass. Both winged and wingless individuals may then be seen. The cottony secretion arises from the abdomen of the insects, serving only as a protection. Its white color serves as a means of locating the aphids, particularly the aerial colonies. In fact, it is believed that the latter are beneficial, rather than otherwise, by serving to indicate that the roots of the trees are also infested, although woolly aphids sometimes occur on the branches without being, at the same time, on the roots.

LIFE HISTORY.

To understand the life history of a colony of woolly aphids for one year, it is best to first consider the forms occurring on the roots in mid-summer. Most of the adults are wingless, agamic females, each giving birth to living young at the rate of from two to twenty a day, until fully one hundred are born, after which the mothers die. They are really non-sexual, and their off-spring develop within eight to ten days into similar, wingless, non-sexual (agamic) females.

These wingless forms are most abundant during the summer. Later in the season some winged females develop, known as the migratory form. Some of them now desert the roots and fly to the limbs above, or to the branches of other trees, to start new colonies which are called the aerial form. These winged forms also give birth to living young which differ from their parents, by developing into true males and females. After mating, each female deposits one large egg in a crevice of the bark, where it remains until the following spring, when it hatches and develops into a wingless agamic form similar to the ones in the colony with which we supposedly started the previous year.

Some of the wingless aphids persist on the roots throughout the year in this state, remaining partially dormant during winter and resume active feeding and breeding the following spring.

Several generations occur each year which shows the necessity of killing the aphids during the spring months, for otherwise they increase to injurious numbers during summer and fall. The writer's experiments have shown that kerosene emulsion is a preparation that not only kills the aphids present at the time of treatment, but acts also as a repellent for several months, thereby furnishing a nearly perfect remedy.

REMEDIAL MEASURES.

Apple woolly aphids, whether occurring on the roots or above ground, are fought by applying some mixture which has a corrosive, penetrating or suffocating effect on the soft bodied insects. Kerosene emulsion or tobacco (in dry form or as a decoction) and potash or lye soap solutions are the most effective for this purpose.

The aerial colonies are easily destroyed by saturating them with twenty per cent kerosene emulsion (see formula page 50) or with a tobacco wash made by boiling the following for two hours:

Fresh tobacco stems or leaves	3 pounds.
Water (after boiling is over) to make	5 gallons.

This wash should be used full strength, preferably while warm, and may be applied with a brush, cloth, or spray pump, taking the precaution to see that the lice under their cottony covering are actually reached.

Previous to the year 1905 the root infesting form was fought principally by applying liberal quantities of tobacco dust or tobacco stems and leaves, depending on its decomposing and ultimately leaching through the soil so that the nicotine might kill or drive away the insects. This method is still in use in many places.

A number of experiments were made by the writer in Georgia during 1905 and 1906, to test the relative value of tobacco treatments, whale oil soap solution, tobacco whale oil soap solution, kainit and tobacco, kainit alone, common salt, carbon bisulphid, and, particularly, kerosene emulsion at varying percentages. Those experiments demonstrated conclusively that kerosene soap emulsion at ten and fifteen percent strength was much superior to all other treatments. During June, 1909, similar experiments were made on apple trees on the Station farm at West Raleigh, when the superior value of kerosene emulsion was again demonstrated. As further proof of its effectiveness several nurserymen have commenced to use it extensively for controlling the woolly aphis on their young apple tree stock.

KEROSENE EMULSION TREATMENT.

Stock Solution.

Kerosene (good grade)	2 gallons.
Common laundry soap or whale oil soap	1-2 pound.
Water (must be soft)	1 gallon.

To prepare: Dissolve the soap in one gallon of boiling water, then remove it from the fire and add two gallons of kerosene and agitate the mixture violently for ten to fifteen minutes. As the kerosene and soap solution combine a smooth creamy emulsion will result. This violent churning breaks the drops of kerosene into such minute globules that the soap is able to hold them in suspension.

A perfect emulsion may be obtained in ten minutes by using a small force pump, equipped with a nozzle having one-eighth inch discharge and pumping the mixture back into itself with considerable force. Emulsion properly prepared will stand several weeks without the kerosene rising to the top. When diluted it requires frequent stirring to keep a uniform mixture.

The stock solution may be diluted to the required strength by adding amounts of water as follows:

For 10 percent emulsion dilute with 17 gallons of water.
For 15 percent emulsion dilute with 10 1-3 gallons of water.
For 20 percent emulsion dilute with 7 gallons of water.

Application.—Fifteen percent emulsion is recommended for general use, although ten percent is often thoroughly effective, and even thirty percent emulsion did not injure the trees in the writer's experiments.

Early spring, after the apple trees commence to grow, is the best time to apply this treatment, for two reasons: First, because it is desirable to kill the woolly aphis at that time; and, second, because while the trees are growing vigorously the kerosene will not cause injury. When the trees are dormant there may be danger that the kerosene will penetrate and injure the roots. Growers are advised not to use it during the winter or late fall.

Prepare the trees by removing the surface soil from around the trunk, to a distance of fifteen inches to two feet or more, and two to three inches deep, or enough to partially expose the infested roots. Then apply fifteen percent emulsion slowly until the soil is soaked to a depth of about three inches. The amount required per tree will vary from one to three gallons. Over four gallons have been applied, by the writer, to the roots of a tree having a trunk only six inches in diameter, without any sign of injury.

After treatment at once replace the surface soil.

The kerosene will reach and destroy all the aphids in the area treated, and the odor, lasting for two or three months, will act as a repellent against re-infestation by aphids from surrounding roots or from other trees.

This treatment should be given while the soil is in good workable condition, neither too wet nor too dry.

TOBACCO AND OTHER TREATMENTS.

Tobacco dust, applied in amounts of from two to ten pounds per tree, or strong tobacco solution, applied in the manner recommended for kerosene emulsion treatment, are claimed by many orchardists to be effective and to have the advantage of being a fertilizer also, but the writer has not found tobacco in any form equal to kerosene emulsion. Kainit or salt is of practically no value. Potash whale oil soap, or tobacco whale oil soap, used at the rate of two pounds to one gallon of water, in quantities of one to three gallons per tree, is partially effective, but very expensive and not equal to kerosene emulsion. Carbon bi-sulphid has a very limited value because it can not be made to spread through the soil without danger of injuring the roots.

TREATMENT OF NURSERY STOCK.

Nurserymen may treat rows of apple trees by applying ten percent kerosene emulsion in a shallow furrow opened on each side, using simply enough to soak around the infested roots.

Orchardists who purchase nursery stock may take the precaution to dip the roots in fifteen percent emulsion before planting to kill any woolly aphis which may be present. When a number of trees are dipped they should not be piled in large heaps, on account of the danger of the drip from the upper trees, running down and accumulating on the ones below, for while the trees are dormant there is some danger of kerosene injury.

ROUND-HEADED APPLE TREE BORER.

(*Saperda candida,* Say.)

Burrowing in the sapwood, and to some extent into the heartwood of apple trees, at, or near the surface of the soil, the round-headed borers sometimes cause severe injury before their presence is discovered. Young orchard trees and nursery stock are most commonly injured because the channels made by the borers cause a partial girdling effect. Two or three borers may kill a young tree while in older trees they may occur without causing serious injury.

The round-headed apple tree borers are quite injurious in the mountain section of North Carolina, but seldom occur in the central or eastern portions of the State.

The presence of borers is evidenced by an area of dried, brown. shrunken bark from which the sap exudes in early spring and sawdust like castings escape through cracks or are extruded by the larvæ from openings into their burrows. Infested trees may present a dwarfed appearance.

Apple and quince are the favorite food plants, but pear is sometimes attacked. Other trees that serve as food for this borer are: crab apple, thorns, mountain ash, choke berry, and June berry. Such trees should not be allowed to stand around apple orchards.

DESCRIPTION AND LIFE HISTORY.

The parent form is a beautiful beetle about three-fourths of an inch in length. The body is pale brownish yellow above with two creamy white stripes extending the entire length of the body, including the head (Fig. 3). The beetles are nocturnal in habit. They appear during May or June and deposit eggs in cracks in the bark near the ground or on the trunk and main limbs.

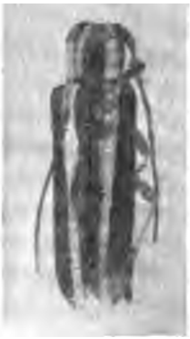


FIG. 3.—Parent beetle of round-headed apple tree borer. (About twice natural size.)

The eggs hatch within two weeks into minute borers which immediately gnaw through the bark and commence to feed on the sapwood.

Borers are fleshy, somewhat grub-like, light yellow in color and cylindrical, with a dark colored head, not much wider than the body. The name, round-headed borer, is given to contrast this species with one closely related, in feeding habits, but possessing a wide, flattened head.

For the first season the round-headed borers confine their attack to the sapwood, making disc-shaped burrows which may reach the size of a silver dollar. At the approach of winter, the borers, as yet only partly grown, go to the lowest part of their burrow, and there remain quietly until the following spring, when feeding again commences. They then enlarge their burrows, extending them partly into the sapwood, and sometimes nearly girdle small trees. The second winter is also passed in the burrow. The third year of the borer's life finds them going deeper into the heart-wood, where, before late fall, they attain full growth, and then, with heads pointing toward the bark, transform to pupæ and remain so until spring. During May or June the pupæ change to beetles, which cut their way out and lay eggs for another generation.

The entire life of this borer covers nearly three years, most of that time being spent in the larval stage.

METHODS OF CONTROL.

The knife is the only certain remedy when borers are discovered in an apple tree. Cutting them out of the sapwood may be accomplished with rapidity and with only slight additional injury to the trees. Since it is known that the first season of this borer's life is passed in a small area of sapwood, and that the second year also is passed in comparatively shallow burrows, it is evident that careful annual inspection of trees and prompt removal of the borers discovered, will prevent serious injury.

Four or five borers often occur in one tree, some at times being located under the bark beneath the surface of the soil; hence when making a search for them the soil should first be pulled away. Round smooth holes, extending into the heart wood, indicate that the adult beetles have escaped, and when such are found open to the surface they may be disregarded, but if discovered underneath the dying bark it means that the full grown borer or pupa is present and can best be reached and killed by inserting a stiff wire.

Aside from the knife remedy, a preventive measure is sometimes adopted to keep the beetles from laying eggs on apple trees. This consists of applying to the trunk and main limbs a coating like whitewash, lime-sulphur wash, (see page 61), or a thick alkili soap solution; (Formula, page 57); or wrap the trees to a height of eighteen inches with thick brown paper or newspaper, tied firmly at the top and dirt piled around the lower edge, and a deterrent wash applied above this protection. Trees should be covered in this manner from May 1 until August, and, when bands are used, they should be removed about September 1 and the trunk thoroughly scraped and wormed to remove any young borers which may have attempted to gain entrance.

It has been reported that the borers in their channels are killed by applying kerosene freely wherever their castings protrude through the bark. However, when an apple grower sees this indication of borers it would seem much safer and almost as easy to use a sharp knife and remove them at once, to be certain of victory.

FLAT-HEADED APPLE TREE BORER.

(*Chrysobothris femorata,* Fab.)

Compared with the round-headed borer, this species is of less importance, although often more numerous. They prefer to work in diseased or dying trees, but undoubtedly hasten or cause the death of trees injured by other insects, or affected by some fungous disease. However, they do not hesitate to attack apparently sound trees, and especially ones that have been recently transplanted, either in the nursery or orchard. Damage is caused by the borers making shallow burrows in the sapwood, similar to those made by the round-headed borer during its first season. The location of the burrows may be detected by the discolored, dried bark, which is often cracked and shrunken in appearance.

Flat headed borers enjoy a wide range of food plants, including apple, plum, pear, peach, oak, maple, hickory, chestnut, linden, willow and others. Besides, they also breed in newly cut timber.

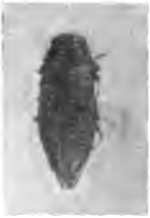


Fig. 4.—Parent beetle of flat-headed apple tree borer.
(About one and one-third natural size.)

DESCRIPTION AND LIFE HISTORY.

The parent form is a beetle about one-half inch in length, with a flattened, oblong body, tapering toward the posterior end (Fig. 4). The color above is greenish black with bronzy reflections while the legs shine like burnished gold; the feet are shining green. These beetles commence to appear during May and persist for several months; they love the sunshine and may sometimes be seen running up and down the tree trunks.

The larval, or borer stage, when fully grown, is a worm nearly one inch long, lying normally in a curved position with the tip of the body close to the head. The segment of the body just behind the true head is much flattened and expanded, giving the appearance of a large flattened head, from which the name has been adopted. The feeding burrows never extend far into the heartwood, but are usually broad, shallow, irregular channels under the bark.

Concerning their life history, flat-headed borers reach maturity in one season, usually passing the winter in their burrows in the pupal condition. The parent beetles may be depositing eggs from May to August.

CONTROL MEASURES.

Apple growers should learn to detect the burrows made by both the flat-headed and the round-headed borers, and adopt the knife remedy when necessary. All statements regarding preventive measures given for the control of round-headed borers apply equally well to this species, except when using deterrent washes, it must be applied to all the largest limbs as well as the trunks of the trees.

Dead, dying or diseased trees, which may serve as breeding places for the borers, should be promptly burned, together with prunings from healthy trees. Such practice tends also to prevent the increase of shot-hole borers.

Orchards located near forests need frequent inspection, in order to remove borers before they cause severe injury.

SHOT-HOLE BORER OR FRUIT-TREE BARK-BEETLE.

(*Scolytus rugulosus,* Ratz.)

This borer belongs among a class with the flat-headed apple-tree borer because of being partial to weakened or dying trees, but nevertheless it is an orchard pest of no small importance. Damage to perfectly healthy trees is not great, but in every orchard there occur some trees which are weakened from various causes, and the shot-hole borers may hasten or cause their death.

It is only since 1877, when first discovered in New York State, that fruit growers have known of this pest. Since then it has spread to all the eastern states and at least as far West as Kansas.

In addition to the apple, nearly all orchard trees serve as food, particularly peach, plum, cherry, apricot, pear and quince. Early writers generally voiced the opinion that the shot-hole borer and its larvæ would not work in a healthy tree. More recent observations, however, have shown that trees, to all outward appearances, perfectly healthy may be attached and weakened.

DESCRIPTION AND LIFE HISTORY.

The parent beetles are cylindrical in shape, very small, about one-eighth inch in length and only about one-third as broad. They are quite uniformly black in color.

The full grown borers or grubs appear larger than the beetles, measuring about one-sixth inch in length. In color they are pinkish white except for the brown head.

The winter is passed in the grub stage in shallow channels beneath the bark. In early spring the parent beetles mature and escape through small round holes scarcely one-sixteenth inch in diameter (Fig. 5). These beetles commence to bore into the bark at the base of buds or lateral spurs, and construct an egg chamber, sometimes an inch or more in length, on each side of which are deposited the eggs, which soon hatch into minute grubs that tunnel out at right angles to the main egg chamber. The grubs seldom make deep channels, but feed in the cambium or the sapwood just beneath.

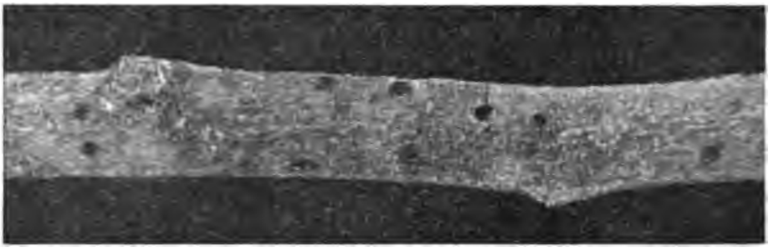


FIG. 5.—Shot-hole borer. Exit holes in apple twig. (Twice natural size.)

Each female deposits about eighty eggs, hence their numbers may increase rapidly.

Three generations are likely to occur each year in this State, and when one considers that each beetle makes a hole to escape and another to construct an egg chamber, besides some holes made by the males simply for feeding purposes, one will realize how soon an infested branch may look as though the bark had been peppered with very fine shot.

REMEDIES.

As already explained these insects seem to prefer to breed in dying trees. Herein lies the clue to a remedy, or more correctly speaking, prevention. All dead and dying trees, broken limbs, and brush made by pruning, should be burned during winter or before March to destroy all the young borers, which are living under the bark, and would otherwise change to beetles during early spring. If this advice is followed, except for the few beetles maturing from slightly infested trees, there can be none to reinfest the orchard the following spring.

The practice of using dead trees and limbs to fill gullies, or leaving them in piles around an orchard for several months before burning, can not be too strongly discouraged. In other words, do not leave dead wood or weakened trees in which the shot-hole borers may breed.

Fertilizers and good cultivation will assist slightly infested trees to recover, after the attacked portions have been removed, and the same is true for trees weakened through other causes. Healthy, rapid growing trees are better able, than poorly nourished, slow growing ones to withstand the attack of this or other insects.

Young grubs under the bark can not be destroyed by any known method except burning, but deterrent and poison washes have been used with some success, to prevent the parent beetles from boring into the trees to deposit eggs. A wash that has been used in the past is made as follows:

DETERRENT AND POISON WASH.

Dissolve as much common washing soda as possible in six gallons of water, and then dissolve one gallon of ordinary soft soap in the above and also add one pint of crude carbolic acid and mix thoroughly. To this add two pounds of lime slacked in two gallons of water, and finally add one-half pound of paris green or one-fourth pound of white arsenic and mix all thoroughly.

The above wash will poison some beetles if they attempt to eat through it. The trunk and large limbs of trees to be protected should be covered from the middle of March to mid-summer, requiring two or three treatments. In general orchard practice such work will hardly be profitable.

Wherever orchards are sprayed with lime-sulphur wash for the San Jose scale, it is probable that no other wash will be needed before mid-summer, or at least, additional treatment would not be practical, because of the expense.

APPLE TWIG BORER.

(*Amphicerus bicaudatus,* Say.)

This twig borer is an insect of small importance compared to many orchard pests, but is often present in apple orchards. It is a cylindrical beetle about one-third of an inch in length, of a chestnut brown color above, and black beneath. In early spring they bore into the small branches of apple, pear and cherry, entering just above a bud and working downward in the pith, evidently for both food and shelter. Such twigs soon wither and their leaves turn brown.

The beetles do not remain long in these burrows, but leave in search of grape vines or green brier, where their eggs are laid and their young reared, in the dead or dying shoots.

Exemption from injury by the twig borer, will generally be secured when all neglected vineyards, wild grapes or brier thickets are not allowed to remain near apple orchards. The usual practice of pruning apple trees to remove all twigs injured by various agencies, is a necessary part of good orchard management and should not be neglected, although this twig borer usually deserts its burrow before such pruning can be made.

SAN JOSE SCALE.

(*Aspidiotus perniciosus,* Com.)

The San Jose scale is the most destructive scale insect in North Carolina. A great deal has been written concerning it, but in spite of this some orchardists are still unacquainted with this insect and its destructive powers. No fruit grower can afford to remain in ignorance of its appearance and remarkable ability to spread rapidly, nor the methods by which it may be controlled should it appear. There are yet in North Carolina some localities where the San Jose scale has not become established; but such places are not numerous and the scale has appeared or will eventually occur in all orchards. This insect is not confined to the principal orchard trees like peach, apple, pear and plum, but thrives on a great variety of trees and shrubs, including currants, roses, mulberry, osage orange and others that are grown in every locality. Apple and pear trees withstand the attack of the San Jose scale better than peach and plum, but even when the insects are not sufficiently abundant to injure the trees materially they may mar the fruit and lessen its selling value.

The name San Jose comes from the town in California where this insect was first discovered in the United States in the early seventies. Subsequent investigations have shown that its original home is Northern China.

DESCRIPTION.

The true appearance of the San Jose scale in its various stages can be detected only by the aid of a strong magnifying lens. When thus examined much variation between individuals will be noticed.

The scale of a full grown female is ashy gray in color, and almost round in outline; it shows in the center of the upper surface a prominence called the nipple surrounded by a darker colored ring (Fig. 6). The nipple is a characteristic of all scale insects belonging

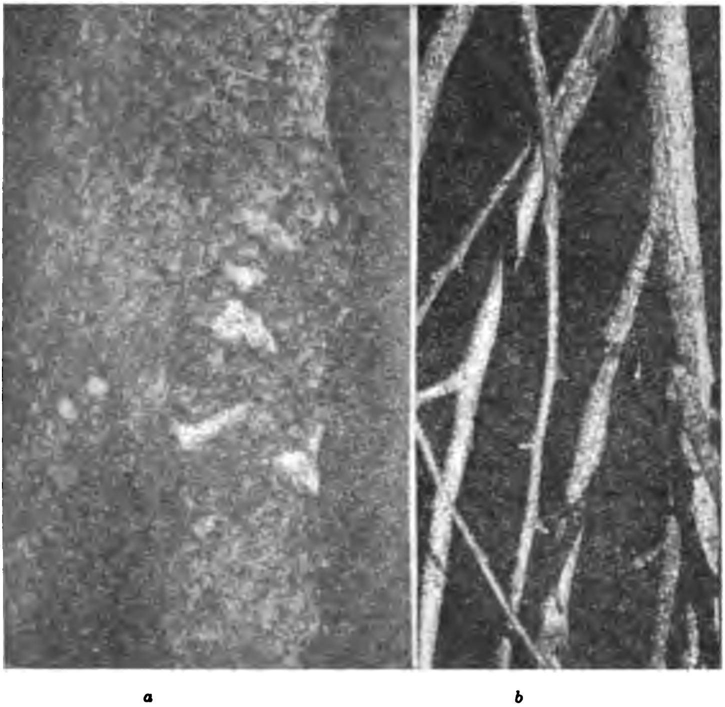


Fig. 6.—San Jose scale, on apple twigs: (*a*, one-fourth natural size; *b*, enlarged five times). Notice circular rings indicating individual scales.

to the same family; it is formed in part by the first molt or cast skin of the young insect; the subsequent scale formation is due largely to secretions from the body of the true insect beneath. The resulting scale is slightly conical, sloping evenly in all directions. Mature scales are about one-sixteenth of an inch in diameter.

The above is a description of the outward appearance of a female scale as it would grow under perfect conditions. When crowded on a branch they often assume widely differing shapes.

The hard scale conceals the body of the true insect. By using a pin or knife point the scale may be lifted, revealing the orange yellow body of the female.

The male scale differs from the female by being smaller, darker in color and nearly twice as long as its width. The nipple is at one end.

Young scales, when about two weeks of age, are almost perfectly round, nearly jet black, and show a prominent nipple surrounded by a grayish ring. They are no larger than a pin hole, but are easily recognized by the aid of a magnifying glass, and at this age are readily distinguished from nearly all other scale insects.

LIFE HISTORY.

Females mature at about five weeks of age and soon commence to give birth to living young, bringing forth two hundred to three hundred within two weeks, and then die. Eggs are never deposited by this species. Young crawling insects are minute in size, oval in shape and of a bright lemon yellow color. They crawl about for several hours in search of a suitable place to commence feeding by inserting their thread-like sucking beak, which is often longer than their body. After once commencing to feed their position is never changed, except in the case of the male which eventually becomes a tiny fly with two wings.

At the age of twelve days the first molt occurs when legs, eyes and antennæ disappear, and the insects under their scale covering then look like tiny flattened yellow balls. The sexes are not distinguishable. Six to eight days later a second molt occurs, and by that time the male scale has commenced to assume its elongated shape and at the age of about twenty-five days the two-winged insect escapes from under its scale covering. The females are about five weeks old when they commence to bring forth crawling young.

WINTER STATE AND HOW TO DETECT INFESTED TREES.

Winter is passed by the San Jose scale as half grown or nearly mature individuals. Mature males and females perish from exposure to the weather. During winter a badly infested tree presents a grey appearance, being about the color of wet ashes. Old dead scales may be closely packed together or piled on top of one another (Fig. 6). Among them will be found the black, circular, half-grown scales as described above. The greatest number of live scales will be found on the least thickly coated portion of the infested limbs and around the base of young shoots and branches.

A characteristic feature of the San Jose scale is that it causes the bark to turn red, especially on the young shoots of some varieties. Isolated scales may cause a blotch, in diameter, several times the size of the scale itself, and when such marks are found with the characteristic round, black or greyish scale in the center, it is good evidence that the true San Jose scale has been discovered. Other scale insects cause red blotches on the bark, but the scales themselves differ somewhat from the forms described.

REMEDIES.

Almost every conceivable material, having any claim to insecticidal value, has been tried to kill the San Jose scale. Whale oil soap solution was at first used with good success, but it has proved too expensive in general practice; kerosene and crude petroleum in mechanical mixture or as emulsions were extensively used in the early fight against this pest, but are no longer considered safe and economical as a winter treatment; the so-called soluble oils, principally a mineral oil treated in a manner to render it easily mixed with water, have been, and are yet, used extensively, with reasonably good results; but the chief reliance is now placed on lime and sulphur preparations, which may be purchased, all ready and prepared to mix with water and be applied as a winter dormant tree spray, or some lime and sulphur wash which the fruit grower may prepare from materials readily obtainable, and use while the trees are not in foliage.

LIME AND SULPHUR WASH.

Formula.

Lime (fresh unslaked)	20 pounds.
(Do not use a magnesia lime.)	
Sulphur (flowers or flour of)	15 pounds.
Water, to make	50 gallons.
Boil for at least one hour.	

Mix the sulphur into a thin paste with a small amount of water, and then add about fifteen gallons more in a kettle or whatever receptable is used for boiling. While this mixture is boiling hot add the lime which immediately commences to slake, causing violent ebullition. (The sulphur may be added to the slaking lime if preferred.) Stir frequently and add cold water, if necessary, to prevent its boiling over. After the lime is slaked continue to boil for at least an hour.

When properly prepared this wash is a dirty green color, *having lost the yellow sulphur color entirely,* but if allowed to settle a clear amber colored liquid appears on top. A residue settles quite readily, but as this is an important part of the mixture, it should not be discarded except that portion which is removed by the straining necessary to make the solution go through the ordinary spray pump nozzle.

The lime-sulphur wash is intended to be used only for winter spraying while the trees are dormant. It will burn the foliage severely, and, if used in summer, it should be applied only to the trunk and limbs. Badly infested trees should be sprayed twice during the winter, once in November or December and again in February; by this treatment the San Jose scale may be nearly exterminated. Trees only slightly infested are usually protected by one thorough spraying in February of each year.

COMMERCIAL LIME-SULPHUR PREPARATIONS.

Several brands of prepared lime-sulphur wash are now being manufactured and sold by different chemical companies. All reliable concerns offering this preparation for sale have a mixture that is practically as effective—if used at the proper strength, usually one part to ten of water—as the home prepared wash, and most fruit growers will find it more convenient, and, in the end, just as economical to use one of them in place of the formula given above.

SUMMER TREATMENT FOR SAN JOSE SCALE.

Summer spraying is sometimes advisable when an orchard is discovered to be infested after the trees commence to grow, but dormant tree spraying, as recommended, is much to be preferred.

The lime and sulphur preparations may be used on the trunk and limbs, without injury to the bark, but foliage will not stand such treatment.

Kerosene emulsion at fifteen per cent strength (formula page 50) will kill a large percentage of the insects, if applied during the summer months. It kills all the young or partly grown scales, but does not usually kill the mature females. It can be applied with safety provided the emulsion is properly prepared and applied on a bright day, applying only enough to cover every branch and twig together with the foliage, without its running down and accumulating around the trunk.

OYSTER SHELL SCALE.

(*Mytilaspis pomorum,* Bouche.)

The oyster shell scale is widely distributed, but is not by any means as destructive as the San Jose scale. It has occurred in the United States over one hundred years, since being introduced originally from Europe.

Full grown female scales are fully one-eighth inch in length, slightly convex and usually curved in outline to resemble a minature oyster shell (Fig. 7). These hardened scales are brownish or grayish brown in color, closely resembling the bark of the tree on which they live, and the true insects live underneath. By lifting a scale the yellow, soft-bodied female may be seen during summer, but in her place, a number of pearly white eggs, during winter.

The scale covering of the male is shorter than the female, and little, if any, curved. The adult male is winged and appears in mid-summer to fertilize the females.

During winter the female scales cover a mass of pearly white eggs, which hatch during the latter part of April or May.

Two generations develop annually in the southern states, but only one occurs farther north.

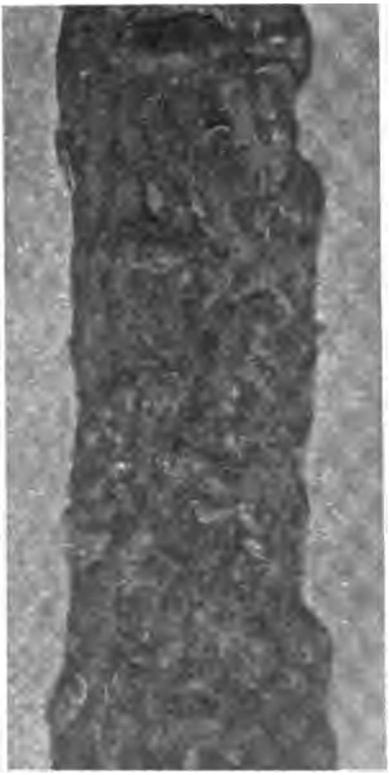


FIG. 7.—Oyster shell scale, on apple twig. (Six times natural size.)

REMEDIAL MEASURES.

It has been found extremely difficult to kill all the winter eggs even by applications of strong kerosene emulsion, lime and sulphur wash, or strong soap solutions such as are effective against the San Jose scale which at that season are living as partly grown individuals. Twenty percent kerosene emulsion will penetrate the oyster shell scales and destroy some eggs; lime-sulphur wash or plain whitewash tends to loosen the scales and cause some to sluff off, thus exposing and killing some eggs, but winter treatment can not be strongly advised.

The most vulnerable period of the life history of this insect is just after the eggs hatch in spring; that is, while the young are crawling about, or soon after they have commenced to feed and secrete their hard scale covering. They are then susceptible to weak contact sprays, such as ten percent kerosene emulsion, common laundry soap, whale oil soap, or lye soap, dissolved at the rate of one pound in five gallons of water. Apple growers should determine when the eggs hatch by watching infested trees after about the latter part of March in order to apply the remedy before the insects become protected by the hard scale covering.

In general practice it will be found profitable to prune off badly infested branches during fall or winter, at the same time marking such trees and others slightly infested, for treatment the following spring.

The above recommendations are applicable also to treatment for the scurfy scale insect.

SCURFY SCALE.

(*Chionaspis furfurus,* Fitch.)

The scurfy scale is more abundant in Western than in Eastern North Carolina. It occurs on both apple and pear, and is readily recognized, when present, by the whitewashed appearance it gives to the trees.

This insect is a native of America, its original home being on the bark of our native crab trees. In power of destructiveness it does not equal the oyster shell scale, and its injury is insignificant compared with the San Jose scale.

The scale of the female is about one-tenth inch long, very flat and irregularly triangular or pear-shaped in outline. The nipple is at the pointed end, which usually points upward. The color is light grayish or whitish, but seldom pure white.

Under this scale the female insect, when full grown, deposits a mass of eggs, in this respect agreeing with the oyster shell scale; but these eggs are purplish instead of white, and the little larvæ when hatched are reddish brown in color.

The scale of the male is pure white, much smaller than the female, and differs further by having parallel sides and three parallel ridges along the back. They usually occur on twigs separate from the females, giving some parts of the bark a whitewashed appearance. The adult male is a tiny winged fly.

Two and sometimes three generations occur each year. Winter is passed in the egg stage only. During April or May these eggs hatch into minute lice which crawl about for a short time, then settle down to feed and secrete the hard scale covering.

Remedial measures consist in pruning off and burning badly infested branches, or applying strong contact sprays during winter to loosen the scales and destroy the eggs beneath, or the use of weak spray mixtures on the newly hatched young which appear about the same time as the oyster shell scale. In fact all treatments suggested for the latter may be used to control the scurfy scale.

GREEN APPLE LEAF APHIS.

(*Aphis pomi,* De Geer.)

One of the most common and persistent pests of the apple orchard, is the green leaf aphis, which lives on the under side of the leaves, causing them to curl, blacken and die. Recently planted orchards and nursery stock are damaged annually, the result being a dwarfed, stunted, deformed growth, or occasionally the death of infested trees. Older trees are also attacked. Control measures are simple and effective when applied at the proper time, which is when the aphids first appear and before the leaves are badly injured.

DESCRIPTION, LIFE HISTORY AND HABITS.

The following description and life history notes are based largely on the work of Smith, of New Jersey, who has made a careful study of the insect.

Winter Egg Stage. The lice of the last generation lay eggs, and in this stage the winter is passed. The eggs are small, black, shiny oval-shaped objects, glued to the terminal branches around the base of lateral shoots or buds.

First Spring Generation. About the time the buds are bursting in spring the eggs hatch into minute insects, and, like all plant lice, they feed entirely on the plant juice, which is sucked through their slender beak.

Plant lice extract much larger quantities of sap than they can assimilate, which results in drops of liquid coming constantly from their bodies, either through the two honey tubes on the upper posterior end of the abdomen or through the anal opening. This liquid is highly prized by ants, which are nearly always found running over and around the aphis colonies. It is a great mistake to suppose that ants eat the aphids or injure them in any way; on the other hand ants often protect and aid some species of lice in return for the sweet liquid, called honey dew, of which they are so fond.

The honey dew is directly responsible for the black, sooty fungous growth which nearly always follows the appearance of the green leaf aphis. The fungus thrives on this honey dew, and soon clogs the breathing pores of the leaves, resulting in their turning brown, withering and dying. In this manner it may prove quite injurious to leaves not actually infested by aphids because such quantities of honey dew drop from aphis colonies to the leaves beneath.

Returning to the aphids just hatched from the eggs, it is found that they increase rapidly in size. Only fifteen days elapse before this generation becomes mature. Each adult is then known as a stem-mother, and is able to give birth to living young at the rate of eight or ten a day until at least fifty are born.

The stem-mothers are all wingless, bright green in color and somewhat pear-shaped, with a body one-twelfth inch long. They are agamic, non-sexual forms, giving birth to living young; true males not being present.

Second Generation.—Differing from the first generation, the second reaches maturity in eight to nine days. Some develop into wingless forms, like their parents, but about three-fourths show development of wings after the third molt. The wingless forms resemble the parents, but the winged individuals are slightly smaller and darker green, some almost black in color.

These winged aphids represent the migratory form, and fly to surrounding branches or other trees to start new colonies. Their young are also produced alive by non-sexual reproduction, as before, but all are again wingless. The wingless aphids of the second generation remain in the original colonies, and about one-half of their young mature with wings, and migrate to start more new colonies.

Third Generation.—The third generation under favorable conditions will number into the hundreds and thousands, both in the original colonies and in those started by the migratory forms. The method of reproduction continues as already stated, except that no more winged lice appear.

Last Generation.—After several generations during the summer and fall while no males appear in the colonies, the last one develops into true males and females, and the latter, after mating, deposit fertilized eggs which remain on the trees during winter and hatch and develop into stem-mothers the following spring.

REMEDIAL MEASURES.

Apple leaf aphids are quite readily controlled by contact sprays applied before the infested leaves curl badly. The spray must come in contact with the lice, and the curled leaves render it difficult to reach them. Arsenical poisons are useless.

Referring to the life history it will be seen that it requires fifteen days for the first generation to mature, and nine days longer before the winged adults of the second generation appear. During these twenty-four days the aphids are confined to the vicinity where the eggs hatched, but soon afterward the winged migratory forms establish new colonies on other branches or other trees. Growers should watch their apple trees and be prepared to kill the aphids when they first appear, or at least within one or two weeks thereafter, in order to accomplish the work before the aphids become numerous enough to cause the leaves to curl badly, besides preventing migration and establishment of new colonies.

Tobacco Decoction.—A tobacco wash, made by the formula on page 49, will kill all the aphids that it touches. A weaker solution is often effective. Young trees and nursery stock are most easily treated by dipping the tips in a bucketful of the decoction. Larger trees must be sprayed.

Several commercial brands of tobacco extracts are offered for sale, and are about equally effective when used at the necessary strength.

Kerosene Emulsion.—This is prepared by the formula given on page 50; and when applied at a dilution of fifteen to twenty per cent it will undoubtedly kill all the aphids that it touches, although in actual practice tobacco decoctions give better results. Kerosene emulsion must be well emulsified, to prevent the oil from separating, and the mixture should be constantly agitated while being used; otherwise some injury to the foliage may result.

Soap Solutions.—Any strong potash laundry soap or soaps prepared especially for insecticide work are effective against apple leaf aphis. They are used at a strength of one pound in from three to six gallons of water, preferably warm. Either whale oil soap, tobacco whale oil soap, or naphtha soap, will be found more effective than common laundry soap when used at equal strength. A solution of home-made lye soap, one pint in four gallons of water, is also a satisfactory treatment.

APPLE TREE TENT-CATERPILLAR.

(*Malacosoma Americana,* Harris.)

Tent-caterpillars are widely distributed and familiar to most farmers, because they make themselves conspicuous by dwelling in colonies and constructing tents or nests in which they rest when not feeding. These nests are often made on apple trees, or on other orchard trees and frequently occur on wild cherry.

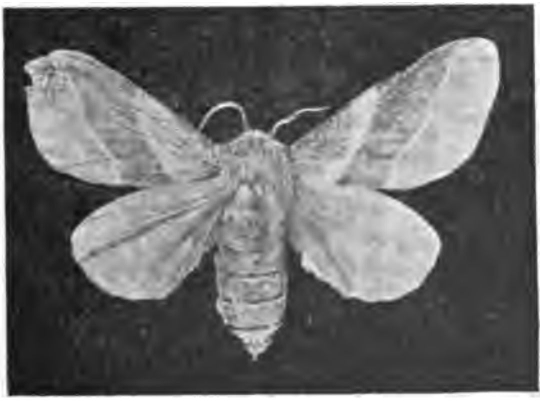


FIG. 8.—Tent-caterpillar moth—female (Somewhat enlarged.)

DESCRIPTION AND LIFE HISTORY.

The parent moths are of a dull reddish brown color, having a wing expanse of about one and one-half inches (Fig. 8). Males are smaller than females, and are also distinguished by having their antennæ more prominently feathered. These moths appear during the early part of June and lay eggs in a characteristic manner. The eggs are deposited on small twigs, in clusters, usually forming a complete encircling ring, containing from two to three hundred (Fig. 9). The eggs are conical, about one-twentieth of an inch in length and placed on end, side by side, in circular rows cemented together and finally covered by the female with a varnish-like substance which protects them during the eight or nine months that elapse before the eggs hatch the following spring.

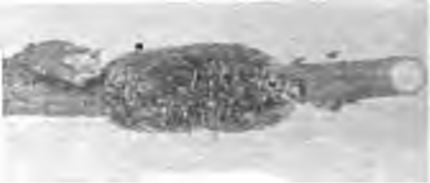


FIG. 9.—Egg-mass of tent-caterpillar. (Somewhat enlarged.)

The young caterpillars hatch early and feed upon the opening buds until the leaves expand. Soon after birth they crawl to the nearest fork formed by three or four branches, but usually within two to three feet of the old egg cluster, and there commence to construct an angular tent or web which is enlarged daily as the worms increase in size and require more room, until finally it may become one foot or more in length. The caterpillars leave the nest to feed two or three times a day, scattering over the tree in search of succulent leaves. They feed only in the daytime of bright days, and have the interesting habit of all leaving, and, later, returning to the nest at about the same time. On cloudy, or rainy days and at night, they remain in the nest. This habit enables the fruit grower to destroy the nest and its occupants without the use of poisons.

Tent-caterpillars attain full growth after feeding for five to six weeks; they are then nearly two inches in length; the body is blackish and hairy, with a continuous white stripe down the back and irregular short yellow lines along each side of this central stripe. A closely related species, the forest tent-caterpillar, has a broken white stripe along the back, and by that feature it may be distinguished from the species under discussion.

When ready to transform the caterpillars leave the trees and scatter in all directions in search of some suitable shelter under which to spin cocoons and pupate.

A cocoon is about one inch long, composed of yellowish silk woven closely inside, but loose outwardly and covered with a powder resembling sulphur. In this structure the chrysalis or pupa stage is assumed and lasts about three weeks, after which the parent moths emerge to mate and deposit eggs, as already described.

PREVENTION AND REMEDIES.

Fruit growers may easily learn to recognize the eggs masses (Fig. 9) on the bare twigs; during winter these may be removed and burned. In spring after the little caterpillars hatch and commence to construct their conspicuous nests every colony in an orchard may be located and destroyed. It should be remembered that this nest is used only as a shelter at night or when the worms are not feeding, hence its destruction must be accomplished while the worms are at home. This time is during the early morning hours, or about sun down, or on rainy days. People frequently make the mistake of burning with a kerosene torch, or otherwise destroying these nests during the middle of the day, with the result that few, if any, of its occupants are present, and the others of the colony, returning later, proceed to construct another nest.

Arsenical poison sprays, such as Paris green or arsenate of lead, used by themselves or with Bordeaux mixture, soon after the leaves expand, will prove an effective remedy by poisoning the caterpillars while they are small. Wherever regular sprayings are made with arsenicals to control the codling moth, apple trees can never be seriously defoliated by tent-caterpillars.

Colonies occurring each spring in wild cherry or other trees, should be destroyed in order to retard the natural increase of the species. The little work required to seek for and destroy them will prove to be time well spent.

FALL WEB-WORM.

(*Hyphantria cunea*, Harris.)

After the fruit grower has successfully routed the tent-caterpillars, his trees may become ornamented with large sprawling webs during June, July and August, and upon investigation these will prove to be the home of hungry, light colored, very hairy caterpillars which are continually extending their web to cover the foliage fed upon. These nests appear on many forest and shade trees as well as apple, pear and plum.

LIFE HISTORY AND HABITS.

The parent moths appear from June to August, coming from pupæ which passed the winter and spring in lightly constructed cocoons spun under the loose bark of trees, and other shelter above ground, or a short distance in the soil. Egg clusters (Fig. 10) containing from two hundred to five hundred eggs are laid on the under surface of the leaves. The young caterpillars devour the pulpy portion of the leaves, leaving the veins and under surface untouched, and spin a web over all the foliage that is fed upon. This web sometimes completely covers small trees and bushes before the worms attain full growth. When nearly grown they desert the web to wander aimlessly about, feeding on various plants before they finally discover a suitable shelter under which to spin cocoons and transform to pupæ.

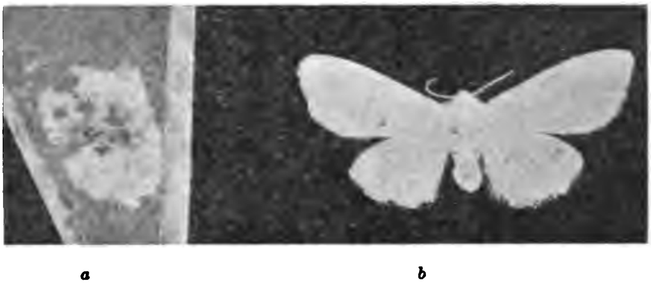


FIG. 10.—Fall webworm: *a*, egg-mass somewhat broken; *b*, female moth. (Only slightly enlarged.)

Two generations occur each year, the first commencing in June and the second about two months later.

DESCRIPTION.

The parent moths are generally snowy white (Fig. 10), although some have dark spots on the fore wings which expand about one and one-quarter inches. The moths are active only at night.

Young worms are pale yellowish in color, sparingly hairy, with a double row of black marks along the back. Full grown worms are an inch in length, pale yellow or greenish as a rule, although some are darker; a black line extends along the back, while the body is clothed with tufts of long, straight dirty white hairs, often longest on the terminal segments. The worms drop quickly when disturbed, suspending themselves by a silken thread.

REMEDIAL MEASURES.

The appearance of webs on the trees is the first intimation of the arrival of fall web-worms. When these are seen apple growers may know that the web and its occupants must be removed and burned, or else the foliage immediately surrounding the webs must be sprayed with an arsenical mixture to prevent further injury. The former method is quickest and certainly effective, and where only a few limbs are infested, as is usually true, it is cheaper to destroy the nest containing the worms than to spray the foliage surrounding them.

Orchards regularly treated with Bordeaux and arsenicals, as recommended on page 86, will not often need additional treatment to control this pest.

CANKER-WORMS.

(*Anisopteryx vernata,* Peck. and *A. Pometaria,* Harris.)

Two closely related species of worms that crawl with a looping motion, like measuring worms, occur at times in this State on both fruit and shade trees. In the worm stage they are almost exactly alike, but the parent moths differ somewhat in appearance and habits, particularly the females. The worms of both species burrow into the soil to pupate. The adult moths of those known as the fall canker-worms (*Anisopteryx pometaria*), emerge in late fall and deposit eggs which live through the winter, while the other species, *Anisopteryx vernata,* pass the winter as pupæ, emerging as moths the following spring, hence they are called the spring canker-worms. Eggs hatch at about the same time in spring which is when the apple leaves are unfolding.

DESCRIPTION.

The female moth of each species is without wings; her body is hardly one-half inch in length, and of an ashy grey color; her movements are slow and sluggish. Upon emerging from the soil the females crawl to the base of some tree, ascend the trunk, and there after mating, deposit broad, flat egg masses on the bark or in some crevice. Each mass may contain one-hundred or more eggs.

The male moths have well developed, brownish grey wings expanding fully one inch.

Full grown worms measure about one inch in length; their color is greenish yellow to dark brown; they do not construct a nest or web, nor live in colonies, like the tent-caterpillars or web worms; and they differ also by walking like a measuring worm. When grown they leave the trees by crawling down the trunk, or dropping by means of a silken thread, and while suspended in mid-air, often get on passing vehicles or pedestrians and are thus scattered over wide areas.

REMEDIAL MEASURES.

Canker-worms present a point in their development quite different from most insects; that is, the females, being wingless, must crawl up the trees to deposit eggs, or, should the young worms hatch near the ground, then they must ascend the tree to reach the foliage. For these reasons barriers that neither worms nor moths can pass, will, if placed around the tree trunks, serve as a perfect protection. Numerous things have been employed for this purpose, such as tree tanglefoot (same material used on tanglefoot fly-paper), printer's ink, coal tar, and other sticky substances, or bands of loose cotton or wool.

Tangle foot is a preparation used extensively in the gypsy moth suppression work in the New England States, and it has proved to be the best and cheapest sticky substance on the market. It may be applied to tree trunks without injury to the bark, and will remain for several weeks, sufficiently soft to catch and hold insects.

Bands of loose cotton may be used by tying them around the trunk, in such a way that the upper edges will hang down over the cord used for tying, so that the wingless females or young worms are entangled and held when they attempt to crawl up the trees.

Coal tar or printer's ink can not be used directly on the bark without danger of injury, although in the past they have been used to cover bands of paper or burlap, but such treatment is not advisable.

Apple growers will seldom have to resort to the above methods to prevent canker-worm injury, even should the worms become numerous. The usual practice of spraying trees two or three times each season with arsenical mixtures, will in most cases suffice to poison the worms before they are large enough to cause injury.

OTHER CATERPILLARS.

In addition to the ones already mentioned a few large species of caterpillars feed on apple foliage, but are controlled readily by the usual sprayings. Over a dozen different forms occur at times, but seldom, if ever, become numerous.

Small caterpillars, representing a wide range of forms and habits, which from their manner of feeding have been given such names, as, leaf rollers, leaf folders, leaf crumplers, apple leaf tyer, and apple leaf skeletonizer, at times become somewhat troublesome on trees which are not sprayed with arsenical poisons; but they can not multiply to injurious numbers where one or two sprayings are given after the trees are in foliage.

The larva of the eye-spotted bud moth is a caterpillar nearly three-quarters of an inch long, which feeds on the blossoms or newly formed fruit; sometimes they feed on the foliage and draw several leaves together in a blackened withered mass. They may also burrow into the pith of the terminal branches. When such injury is observed the infested twigs or bunches of leaves containing the worms should be picked off and burned.

Another caterpillar with curious habits is the apple tree case-bearer. As the trees commence to grow in spring these little curved pistol-shaped cases, each containing a worm, may be found sticking to the fruit buds. The inside of fruit buds are first devoured; later the caterpillars transfer their attack to the foliage, where growth is completed, after which they transform to pupæ, and, during June and July the parent moths appear and lay eggs on the foliage, and the larvæ, hatching therefrom, feed on the leaves until late fall, when they attach their protecting case to some twig and remain dormant until the following spring.

Injury from all these smaller caterpillars is largely prevented. wherever apple trees receive the two or three sprayings with Bordeau mixture and arsenicals, which are necessary to control the apple worm.

CODLING MOTH OR APPLE WORM.

(*Carpocapsa pomonella,* Linn.)

The worms occurring so often in apples, and sometimes in pears, represent one of the most serious obstacles to successful apple raising. They are the young, caterpillar stage, of a small moth. Pears, peaches, plums, quinces and cherries have been found infested with this worm, although apples are their customary food.

The name applied to the parent form has been in use since 1747, when it was first employed by an Englishman named Wilkes. The name is now so common that nearly all apple growers use it when referring to the worm itself.

The annual loss attributable to the codling moth in the United States is estimated at nearly $12,000,000, or, in other words, about one-fourth more marketable apples would be raised were it not for this pest. The percentage of annual loss is greatest in the smaller orchards, owing to the usual neglect of the trees, when only a few are grown to furnish fruit for home consumption. In North Carolina where apple raising is a promising industry, although really in its infancy, the annual percentage of wormy apples is undoubtedly higher than the average for well managed orchards, and since it is well known that two annual sprayings with a suitable poison mixture will reduce the number of wormy apples to less than ten per cent, further arguments for the adoption of spraying are totally unnecessary.

LIFE HISTORY AND DESCRIPTION.

An intimate knowledge of the habits of the apple worm, regarding when and how they enter the fruit, in what stage they live through the winter months, when eggs are deposited, and other facts relating to their development, is necessary for a thorough understanding of the methods of control by spraying, banding, et cetera. Brief mention of each stage of development is therefore advisable.

Parent Moth.—The moths are seldom observed because they remain hidden during the day, and become active only about sundown or later. They are small moths with a wing expanse of not over three-fourths of an inch; their general color is brown, marked with gray; each front wing bears a dark brown spot near the tip (Fig. 11). When resting on the bark of a tree with wings closed, they are not readily seen. Shortly before dusk they commence to fly about the trees for the purpose of mating or laying eggs as described below.

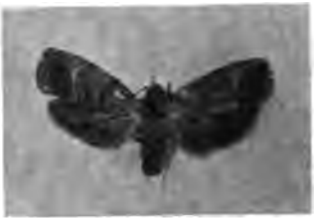


FIG. 11.—Codling moth: parent of apple worm.
(About twice natural size.)

Eggs.—Eggs for the first generation are deposited about ten days after the petals of the apple blossoms commence to fall, the exact date varying with the season. Each egg is about the size of a small pinhead and is pearly white when first laid, but assumes a darker color as the larva develops within. It is now known that over eighty percent of the eggs are laid on the upper surface of the leaves, while less than ten percent are placed on the young fruit and the remainder occur on the under surface of leaves or on the twigs. Each female is thought to deposit about fifty eggs, which hatch in from five to ten days.

Larvæ.—When first hatched the tiny worms commence instinctively to search for the fruit. Before careful observations had been made, it was supposed that most of the worms hatched on the fruit and entered at the blossom end, but now it is known that the majority hatch on the foliage, and a large percent never reach the fruit. The worms endeavor to conceal themselves, so that, when once on the fruit nearly eighty percent crawl into the blossom end where they feed for a short time before burrowing toward the interior. Other worms commence to feed where two apples touch or where a leaf lies against the fruit, or they may feed for two or three days on the foliage.

Full grown worms are flesh colored and about three-fourths of an inch long; they have eight pairs of legs, and in this way may be distinguished at once from the plum curculio worms, which occasionally infest apples, because the latter are legless grubs. When inside the fruit, apple worms work mainly around the core, but when grown and nearly ready to spin cocoons they burrow directly toward the skin, usually to one side of the fruit (Fig. 12). This exit channel is plugged with particles of excrement for two or three days, until the worm is ready to emerge and seek a place to spin a cocoon and pupæ. They remain in the fruit from thirteen to forty days, depending largely on the weather conditions; those of the second generation mature more quickly than the first.

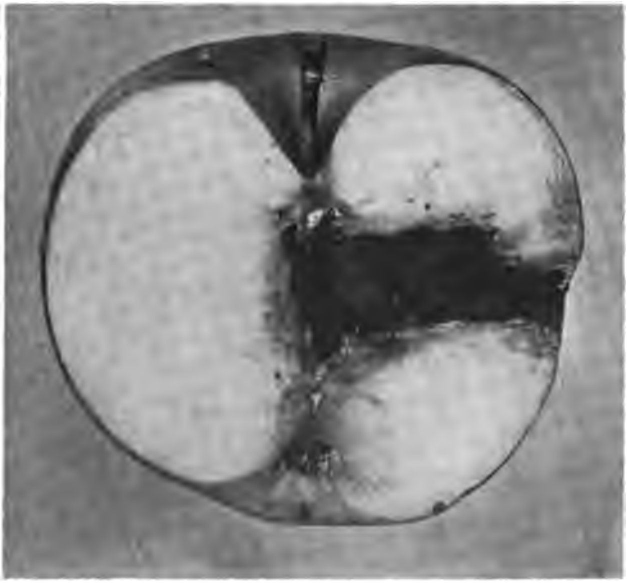


FIG. 12.—Apple worm injury, showing common condition of apples from uncared-for trees. (Somewhat enlarged.)

Cocoons and Pupæ.—After leaving the fruit, if on the tree, the worms may crawl down the limbs and main trunk, or drop to the ground by a silken thread and then ascend the tree in search of sheltered places under loose bark or in cracks and forks made by large limbs, or they may seek shelter in some rubbish on the ground. The worms emerging from fallen apples may crawl up the tree or seek shelter elsewhere.

The cocoon is finally made to fit the crevice into which the worm crawls. It is composed of smooth white silk within, while on the outside the silk is mixed with particles bitten off by the worm in hollowing out a cavity for its body. In these cocoons the worms of the spring generation soon transform to pupæ, and, about two weeks later, emerge as adult moths; but the worms of the second generation usually remain in their cocoons all winter without pupating until the following spring, when the moths appear just after the apple blossoms fall.

Winter Stage.—The reader now knows that the worms hibernate in their cocoons during winter, but it may not be realized that these cocoons may be found wherever apples have been stored during the summer or early fall. Twenty or more cocoons may occur under a hoop of a barrel in which apples have been kept, while the cracks and corners of boxes or apple bins furnish excellent hiding places. When constructed under loose bark (Fig. 13) a large percent of the cocoons are discovered by woodpeckers and other birds that consider the little worms as dainty morsels.

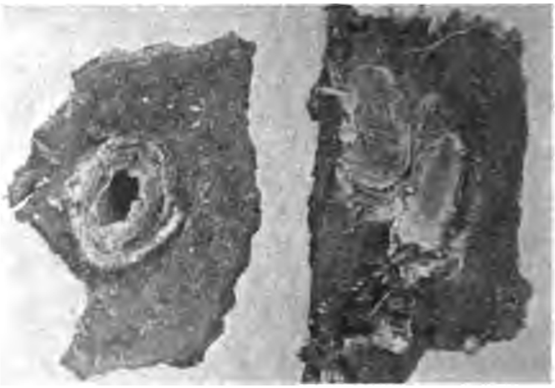


FIG. 13.—Cocoons of apple worm, constructed under bark of apple tree. (Somewhat enlarged.)

Generations.—Two full generations occur in this State; farther South there is a third; while in the North only one full generation develops each year. The first generation are grown and commencing to mature to adult moths about seven weeks after the apple blossoms fall, so that in case the fruit grower desires to spray to poison the larvæ of the second generation, as suggested under remedial measures, this time is reckoned upon unless the worms are induced to spin cocoons under bands, where they may be examined frequently and the exact date of the emergence of moths determined.

REMEDIAL MEASURES.

Value of Spraying.—Spraying with arsenical poisons, preferably combined with Bordeaux mixture for the control of fungous diseases, is by all means the best remedy. The results obtained depend entirely on the applications being made at the proper time, and with sufficient care to cover the foliage and young fruit, in order to poison the worms during the first two or three days of their existence, that is, before they actually enter the fruit. This treatment is based on the fact that fully seventy-five percent of the young worms that hatch on the fruit, or reach it from the leaves, enter the calyx end (blossom end), and feed for a short time in the cavity formed by the calyx lobes where poison can be placed by thorough spraying just after the petals fall, but before the calyx lobes commence to close (Fig. 15). In other words, the principal effective spraying must be finished within ten days after the apple blossoms commence to fall freely. Where a large number of trees must be treated it is necessary to commence the spraying before all the petals have fallen, in order to complete the work before the calyx lobes close, but with only a few trees to be treated the first spray should be applied immediately after the blossoms fall. As this spraying

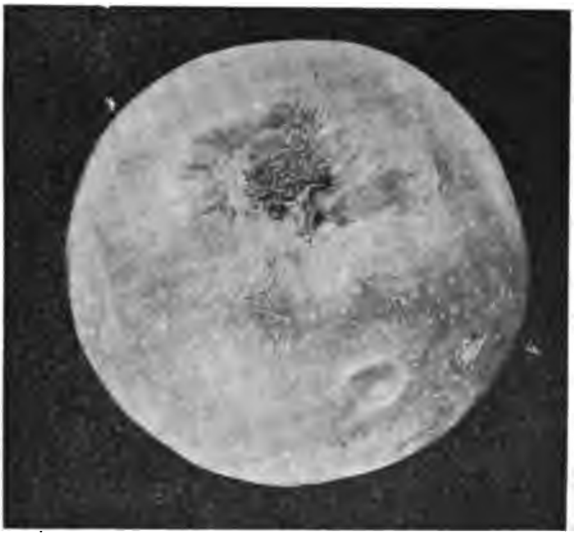


FIG. 14.—Apple worm injury in blossom end. This specimen was not inhabited by a worm when photographed, but shows how fruit may be ruined for market. (Natural size.)

is of great importance against apple scab (page 87), it is best to spray while some petals are still falling.

For best results a second spraying with arsenical Bordeaux mixture should be applied one week after the first, although numerous experiments, conducted in different states, have shown conclusively that one thorough spraying before the calyx lobes close, will reduce the number of otherwise wormy apples, by nearly eighty percent. If both the first and second sprayings are applied at the correct time, it is often possible to secure from ninety-five to ninety-eight percent of apples, entirely free from worms.

Under some circumstances it is advisable to spray to poison the second generation, of which a large number of the larvæ enter the apples from one side instead of the calyx end; but the first spraying, applied thoroughly, is worth more—prevents more wormy fruit—than a number of similar applications after the apples have grown until the calyx lobes are tightly closed. The second generation of apple worms may commence to hatch about seven weeks after the date when the first spraying should be completed, which is approximately nine to ten weeks after the apple trees first commence to bloom. To the writer, it does not seem advisable to attempt spraying for the second generation, unless the grower is sufficiently interested to watch the development of the first generation, and thus know exactly when an application of poison will be most effective. Fig. 14 shows the work of a worm of the second generation, that could probably have been prevented by good spraying.

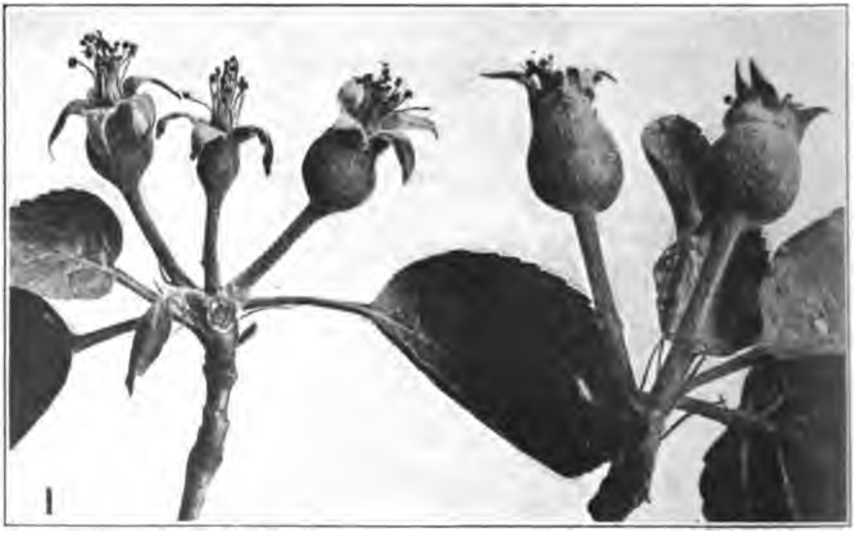


FIG. 15.—Young apples showing, on left, calyx lobes open, and in right condition for first spraying. on right, calyx lobes closed, and almost, if not quite, too late for first spraying. (After Quaintance.)

Arsenical Bordeaux Spray.—The most satisfactory spray mixture for codling moth treatment is prepared as follows:

Formula.

Blue stone	4 pounds.
Lime (must be fresh unslaked)	4 pounds.
Arsenate of lead	2 1-2 to 3 pounds.
or	
Paris green	6 ounces.
Water to make	50 gallons.

The blue stone and lime are combined to make Bordeaux mixture, by the method described on page 119. The arsenical poison, preferably arsenate of lead, is added to this and thoroughly mixed. The poison should be mixed at first in a small amount of water, and then added to the Bordeaux mixture.

How to Spray.—When spraying to prevent wormy apples the poison mixture must be applied as a rather fine driving spray, under high pressure, and directed primarily at the fruit, with the intention of getting some of the poison liquid in the end of each apple where the calyx lobes form a tiny cup. At the time this treatment is necessary the apples nearly all point upward, so that the calyx cup holds the liquid, provided the spray nozzle be set at an angle in order to drive the spray from the sides and from above, directly into the end of the fruit. When all the work of spraying is done from the ground, with the spray nozzle pointing upward, many apples will be touched on the sides while none of the poison will lodge in the calyx cup formed by the open lobes. All the foliage will be covered by the time the fruit is properly sprayed, and, in fact, the mixture must usually be applied until it drips from the leaves before thorough spraying is accomplished. The beginner will feel that a large amount is being wasted, and will be inclined to leave a tree before all the fruit is touched. It is poor economy to attempt to save material when spraying for the codling moth. One very thorough spraying is more effective than two poor ones.

Banding Trees.—The banding method consists of placing strips of burlap or similar material around the trunk and main limbs of apple trees to furnish a place for the worms to spin cocoons and pupate after leaving the fruit. It can not prevent injury by the first generation of worms. In practice the bands are placed around the trees within three weeks after the blooming period, and examined at least twice a week after the worms reach maturity and commence to leave the fruit. This inspection is continued as long as worms are caught in sufficient number to pay for the trouble. In some instances, when trees have not been sprayed properly, large numbers of worms are trapped under the bands and are readily found and killed by crushing, but, as a means of securing fruit free from worms, in the opinion of most apple growers the benefit derived is not equal to the trouble and expense. An experiment conducted in Georgia by W. V. Reed showed that only about ten percent of the worms actually leaving the apples, are caught under bands placed around the trunk and main limbs; hence, even where trees have not been sprayed, a sufficient number of worms pupate elsewhere, and change to adults, to furnish a destructive second generation.

Disposal of Fallen Fruit.—Many of the apples that drop within one or two months after the fruit is first formed, are infested by apple worms, hence some method should be adopted to destroy such fruit in order to prevent the worms from becoming mature and leaving to spin cocoons and change to adult moths. Young hogs will do the work admirably, if they are not allowed too much other food and a sufficient number employed to keep the fallen fruit picked up clean each day.

Preventive Measures.—All rubbish, weeds, brush, or any material that offers a good shelter for the apple worms to spin cocoons, should be kept out of the orchard, or at least carefully cleaned up and burned during the winter. In this connection it should be explained that the trees themselves may be kept free from loose bark, and broken limbs, which offer hiding places for the worms. The lime-sulphur wash, as a remedy for the San Jose scale, tends to keep the bark bright and clean, and Bordeaux mixture has the same effect.

Other preventive measures, such as destroying the apple worms in their cocoons in boxes, barrels and bins where apples are stored or having the storage rooms tightly screened to prevent the escape of codling moths which emerge from such places in spring, and scraping the loose bark off of old apple trees during the winter. will all help reduce the number of the first generation. Poison spray, as suggested, is really a preventive measure, because it kills the worms before they enter the fruit.

PLUM CURCULIO.

(*Conotrachelus Nenuphar,* Hbst.)

Apples and pears frequently show curculio injury, in the form of hard, knotty swellings on the skin of the half-grown or maturing fruit. The worm stage of the curculio is seldom found in these fruits on the trees, but is very common in peaches, plums, cherries or other stone fruits. The adult curculios have been bred, in some experimental work, from small apples that dropped before attaining one-fourth size.

DESCRIPTION AND HABITS.

The curculio is a small, dark-brownish, rough-backed beetle, only one-fifth of an inch in length (Fig. 16); the head bears a slender snout or beak fully one-third as long as the body; the small biting jaws are on the end of the snout; the beetles resemble a dried bud, when playing "possum" with legs and snout held tightly against the body, as they appear when disturbed. It is this habit, of which advantage has been taken, to jar the beetles onto sheets stretched under the trees, and at one time that was the best known method of fighting them.

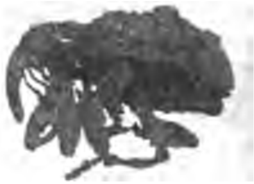


FIG. 16.—Plum curculio: adult beetle. Notice long beak, on end of which are the biting jaws. (Enlarged six times.)

The white, footless, grub-like worms commonly occurring in peaches, plums and cherries are the young of the curculio described above. The common apple worm differs by having eight pairs of legs, and is usually of a pinkish color.

During the winter months the adult curculios hibernate in some sheltered spot, emerging in spring about the time fruit trees are in bloom. They feed at first on the tender leaflets by eating small holes, but later they commence on the fruit, on which the eggs are laid in crescent-shaped punctures. Stone fruits are most acceptable, but apples are attacked if convenient. Both egg and feeding punctures are made in the skin of the young apples. If the egg hatches the worm usually causes the apple to drop within a short time afterward; some of the early drop may be attributed to this cause. However, most of the punctures develop into hard, knotty scars and spots which become noticeable when the fruit is about one-third grown, and are still evident when the fruit is gathered.

REMEDIAL MEASURES.

Apple growers can not afford to make any special fight against the plum curculio, except by such regular sprayings as are necessary for the control of the codling moth, and the practice of frequent shallow cultivation during May, June and July, as explained below.

Concerning the value of poison spray, it has been learned within recent years that a large percent of wormy peaches are prevented by spraying with arsenate of lead, and furthermore, wherever apple trees are well sprayed with any arsenical poison for the codling moth, the curculio injury is much less than on unsprayed trees.

The value of frequent shallow cultivations is due to the fact that the plum curculio larvæ go into the soil to form cells in which to pupate and transform to the adult beetles, but before this change occurs they remain under the surface for nearly three weeks, or sometimes longer, and during that time many may be destroyed by frequent cultivation, which is also most advisable for the health of the trees.

It is doubtful if an apple grower can afford to make any special effort to destroy the young fallen apples which may contain the curculio larvæ; but the usual method of gathering windfalls to destroy the common apple worm, will aid somewhat toward suppressing the curculio.

Whenever apple orchards are planted in among, or close by stone fruits, every effort should be made to suppress the curculio on the latter, by following the best advice, or information obtainable, and thus protect the apples from the chance of being severely disfigured by curculio. The writer can not use space here to discuss the treatment for curculio in peaches and plums.

APPLE CURCULIO.

(*Anthonomus Quadrigibbus,* Say.)

Very few apple growers in North Carolina have seen and recognized the true apple curculio, although it is occasionally present. The adult is a beetle somewhat similar to the plum curculio in general color and shape, but differs by being slightly smaller, and possessing a much longer snout; besides, it has a different manner of development. The plum curculio larvæ desert the fruit to burrow into the ground to pupate and transform into the adult stage, while this species passes through all its transformations in the flesh of the apple.

Concerning possible remedial measures there is little to be said. The apple curculio is not of much importance at present, but if it should occur in injurious numbers, some of the measures recommended against the plum curculio, will be found of value.

INSECTS INJURIOUS TO PEAR.

The pear industry in North Carolina has not been, in the past, sufficiently extensive to stimulate all growers into taking much interest in the insect pests, but as the orchards increase it will become necessary. The following insects, liable to injure pear, are discussed with the knowledge that none of them are of great importance in this State, with the exception of the San Jose scale, borers, codling moth and curculio.

BORERS.

The round-headed and the flat-headed apple-tree borers, the former discussed on pages 52-54, and the latter on page 54 are liable to attack pear trees, but they seldom prove as injurious as when working in apple trees. The remedial measures already advised are equally applicable for borers in pear trees.

The apple twig-borer is also an enemy of pear trees. It is discussed on page 57 with remedial suggestions.

PRIONUS BORERS.

(*Prionus laticollis*, Drury, and *P. umbricornis*, Linn.)

A large borer, often two and a half to three inches in length, is sometimes found in the base of a young pear or apple tree, or in the root of a grape vine. The borer in question has a heavy and prominently segmented body, yellowish white in color; the head is reddish brown in color and small, but provided with powerful jaws. It is supposed that this borer requires nearly three years to attain full growth, then changes to a whitish pupa, thence to the adult beetle.

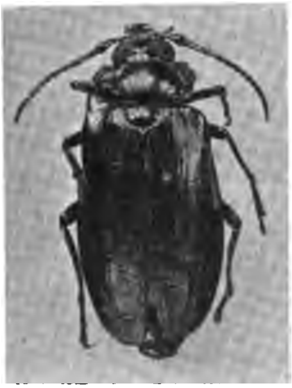


FIG. 17.—Prionus beetle. *Prionus laticollis*. (Natural size.)

The injury is peculiar in that the entire inside of the main root of a young tree may be devoured, while only a thin outer covering remains unbroken until the weight above breaks it over. Nursery stock, and occasionally young trees in the orchards are destroyed in this manner.

The borers of the two species named above resemble each other very closely, and the parent beetles are also much alike. They are large, powerful, brownish black beetles measuring from one and one-quarter to one and three-quarters inches; their heads are narrower than the thorax, and provided with strong jaws. Fig. 17 illustrates the general appearance of these prionus beetles.

There is no preventive measure to suggest, except to kill the borers and parent beetles when found. A young apple or pear tree is generally ruined by the time the borer is discovered.

SAN JOSE SCALE.

Some varieties of pears, particularly the Bartlett and Seckel, are often seriously injured by the San Jose scale, while the Keiffer, Le Conte and some of the hardiest varieties may sometimes grow in a peach or plum orchard where the scale is abundant without becoming infested or being injured in the least. However, this scale is usually a serious pest in mixed pear orchards, but it may be controlled by thorough spraying with lime-sulphur wash, and a study of the San Jose scale discussion on pages 58 to 62 will furnish the necessary information.

OTHER SCALE INSECTS.

The oyster shell scale, discussed on page 62, and the scurfy scale insect, page 64, are liable to occur on pear trees, although they seldom cause severe injury. In case they are discovered the remedial measures suggested will be suitable for treatment of the pear trees.

LEAF-EATING CATERPILLARS.

Pear foliage is subject to the attack of several different forms of caterpillars which may appear in early summer or fall. The fall web-worm, discussed on page 69, is an example, while several caterpillars of minor importance, such as, the tussock-moth caterpillars, the red-humped apple tree caterpillar, and the bag-worms may be present. In all cases of caterpillar attack no damage will occur if arsenical poison sprays are employed. Arsenate of lead at a strength of three pounds in fifty gallons of water or Bordeaux mixture is a safe treatment. Paris green at the rate of one ounce to ten gallons of spray mixture is also effective, but is washed off of the foliage by rains more quickly than the arsenate of lead. The sprayings with Bordeaux mixture necessary to prevent leaf diseases, will also control practically all caterpillars, if arsenical poisons are added.

CODLING MOTH AND PLUM CURCULIO.

Pears are less liable than apples to be found wormy, but the worms which do occur are generally the larvæ of the codling moth, or in other words, the apple worm. Since this pest is fully described and remedial measures explained on pages 73-80, it needs no discussion here. Pears should be sprayed at the same time, in relation to the blooming period, and in the same manner as apples, to prevent wormy fruit.

The plum curculio may cause blemishes, and hard spots on the pear as well as on the apple. This form of injury, as well as remedial suggestion, is explained on page 80, to which the reader is requested to refer.

PEAR-LEAF BLISTER-MITE.

The blister-mites are minute creatures—more like spiders than true insects—that live in blackish blisters on the leaves of pear trees during summer and fall. When abundant they weaken the tree and reduce the crop.

Life History and Habits.—The mites appear on the leaves as they are unfolding in spring, and form red spots or blister-like galls, which have small openings on the under side of the leaves. Eggs are laid within the galls and the young escape through the opening and start new galls. As the season advances the blistered areas change from red to blackish in color, and in the autumn the mites leave the galls and locate in the outer scales of the winter buds, where they remain until the following spring.

Remedies.—The use of lime-sulphur wash (page 61), while the trees are dormant, will destroy nearly all the mites wintering in the buds, as explained above. Twenty percent kerosene emulsion (page 50), applied during the winter, is also a good remedy, but advisable only in case a pear orchard has been badly injured by the blister-mite, and where no San Jose scale exists, to require the lime-sulphur spray; in other words, the latter is the best remedy, as the mixture has a fungicidal value also, without any possibility of causing injury.

GENERAL SPRAYING RECOMMENDATIONS.

The fruit grower should have a clear idea of his reason for spraying, based on a study of the insect enemies, previously mentioned, and the fungous diseases discussed in the following pages; but when commencing he may be guided by the following:

First Spraying. Before leaf or blossom buds open, using lime sulphur wash (page 61), if San Jose scale are present or suspected; or with Bordeaux mixture of (4-4-50) formula (page 119). The lime-sulphur wash has the combined advantage of killing the San Jose scale and other insects that hibernate on the trees, and being nearly equal to Bordeaux mixture in its fungicidal effect.

Second Spraying.—Immediately after most of the petals fall, using arsenical Bordeaux mixture (page 79) for codling moth, bud worms, caterpillars, or apple scab and other fungous diseases.

Third Spraying.—Within one week to ten days after second treatment and using the same mixture; for codling moth, caterpillars, apple scab and other fungous diseases.

Subsequent Sprayings.—All sprayings made after the above, should be applied for a special purpose, such as treatment for the second brood of codling moth; additional sprayings to control the apple scab or leaf spot; or for the control of apple bitter rot; and possibly to destroy unexpected insects like fall web-worms, apple lice, and other forms. A fourth, fifth and sixth treatment is suggested on page 110 for control of apple diseases, and such sprayings are usually profitable if applied for a specific purpose. Arsenical poisons can always be used with Bordeaux mixture, or with the other fungicides mentioned on pages 119 to 123.

II.—FUNGOUS DISEASES OF THE APPLE.

BY F. L. STEVENS.

Original illustrations by
J. G. HALL.

THE APPLE SCAB.

(*Venturiose*).

This disease, collected in North Carolina by Curtis as early as 1867, is prevalent in all sections and is so well known to all apple growers as to need no description. Its general characters are well shown in Fig. 18.

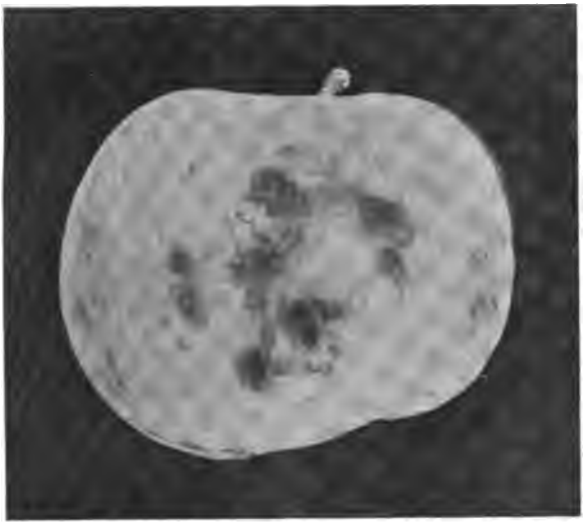


FIG. 18.—Apple scab.

The scab is caused by a parsitic fungus, which does great damage to the leaf as well as to the fruit. The spores, carried by the wind, fall upon the surface of the fruit, leaf or twig and there begin to grow, spreading from the central point of infection. Thus the diseased area is usually circular in outline. Upon the fruit the fungus grows between the skin and the underlying tissue and robs the growing parts of nourishment, causing the diseased regions to grow more slowly than other parts of the fruit. If scab occurs upon the stem of the apple, it so cuts off the supply of nourishment from the young fruit as to cause it to fall prematurely. Similarly the presence of the fungus on the stem of the leaf may cause the death of the leaf. As the apple approaches maturity, the scab, if very abundant, dwarfs one side, giving the fruit a lop-sided appearance, which is quite characteristic. Owing to the premature falling, many apples affected most seriously with the scab escape observation.

Not only does this fungus damage the fruit, but it is also oftentimes present to a very serious extent on the leaves, where it causes a crinkling and an irregular ruffling accompanied by an olive discoloration. Here it interferes greatly with the proper accumulation of nourishment and results in a poorly fed tree the following year The failure of the apple crop can often be traced to poor nourishment the previous year, due to the presence of the scab fungus on the foliage.

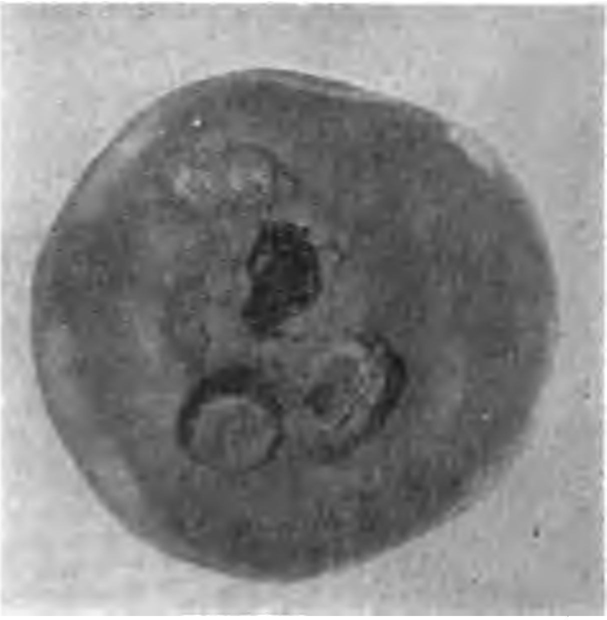


FIG. 19.—Apple scab followed by pink mould. This mould gains access through injuries in the skin caused by the scab. This apple is also suffering from injury by the worm of the codling moth.

While there is serious loss to the apple grower through the attack of the scab fungus upon the leaves and through the premature fall of apples directly traceable to the scab, the presence of the scab upon the mature fruit itself is probably the most serious injury. As was stated above, the diseased area develops poorly. Many scabs on the apple thus result in a marked diminution in the size of the fruit; but more important than this is the unsightliness of the diseased apple, which falls considerably below perfect fruit in market value. Examination of apples in the bin in winter or spring shows further that in many cases the scabby regions rest in the center of the rotten portions. In fact, the scab so destroys the skin of the apple as to permit the entrance of other fungi which cause soft rot. Frequently whole barrels may be found in which every apple is scabby and nearly every scab is surrounded by a rotten area, varying in diameter from one-fourth to one inch or more, and eventually involving the whole fruit. In such apples the rot owes its presence to the scab, which prepared a way for its entrance into the otherwise healthy fruit.

Treatment.—Apple scab can be prevented by spraying with the Bordeaux mixture. It is advisable to spray from two to four times, according to the season. The first application should be made just before the buds open, followed by a second application when nearly all of the blossoms have fallen. A third application should follow eight or ten days later. Winter spraying on the dormant wood, if the ground be soft, may result in injury to the roots by the wheels of the sprayer.

The Bordeaux mixture should be made of four pounds of copper sulphate, four pounds of fresh lime (avoid air slaked lime), and fifty gallons of water. With the second spraying add six ounces of paris green or two and one-half pounds of arsenate of lead to every fifty gallons of mixture, in order at the same time to prevent damage from the codling moth. (See page 73.) Probably the Bordeaux mixture does not kill the scab when it is once upon the leaf or apple. Its chief value lies in *preventing the attack,* and in checking the spread. It should therefore be used early, placing all value upon prevention and expecting no actual cure.

One apple grower reports an increase of one thousand dollars in product from spraying, at an outlay of between \$125 and \$150. In the single State of Illinois, the apple scab is estimated to have caused \$6,000,000 damage in one year, or 60 per cent of the total loss to the apple crop through all enemies. The value of spraying is brought out clearly in the following table, which presents results obtained in Missouri:

	Sprayed	Unsprayed.
Clean	83.5	33.6
Scabby	16.5	66.4
Salable	92.9	69.0

BLIGHT OR FIRE BLIGHT.

(*Bacillose*).

The blight, while one of the most serious of pear diseases is much less injurious to the apple, although even here it oftentimes does great damage, frequently causing dead spots on the trunks of the trees and blight of the succulent branches and twigs.

Upon the twigs its presence may be recognized by the blackening of the bark and the wilting of the leaves as though stricken by fire.

In the winter the diseased twigs are rendered very conspicuous by the retention of the withered leaves long after the healthy leaves have fallen. Very great damage also often occurs to the blossoms. The crab varieties are especially susceptible.

This disease, being pre-eminently a pear disease, is discussed more fully under pear. It may be said here that the disease is caused by a germ belonging to the great group of bacteria. These germs are extremely small and multiply with very great rapidity.

Under ordinary conditions, the disease is spread largely by insects which visit the blighted twigs for the sweetish liquid found on the bark. The insects then fly to another twig or blossom, bearing the germs with them.

Treatment.—The remedy consists in removing and burning all of the diseased twigs. In doing this, great care should be taken to cut low enough to insure the removal of all germs. The limit of the diseased portion can generally be told by the blackening of the bark, but it is usually best to cut a full foot below the diseased part, to avoid all possibility of leaving germs behind. It is also well to dip the knife in a solution of carbolic acid each time, before cutting into new twigs, otherwise, perchance, germs may be left on the knife to be transferred with the next cuttings to other twigs. Dipping the knife in five percent carbolic acid precludes any such possibility.

The best time to trim for the fire blight is in the early spring, when the new wood is succulent and green. At that time the leaves and young shoots affected by the disease may be readily recognized. Careful and thorough trimming during the early spring and summer will prevent the greater part of the blight, but close attention should be given weekly through the remainder of the year to hold the disease in check. In cases where large branches are removed and much surface exposed, the wound should be sealed, either with a grafting wax or with oil shellac, to which has been added a little flowers of sulphur and a few drops of carbolic acid. This mixture may be applied with a paint brush.

It is a matter of common observation that trees in rich soil, which grow too rapidly, are more often affected by the fire blight. This is due to the fact that in such conditions the twig is more succulent, and hence less resistent to invasion by the germ. The fire blight also affects the pear, hawthorn and service berry, and these must all receive attention in order to eradicate the pest. (See Pear, page 111.)

HYPOCHNOSE.

This disease affects the apple, pear and quince. It has been frequently referred to the experiment station for diagnosis and treatment, and seems to be one of the worst diseases occurring on neglected trees in the humid portions of the State.

Viewed from some distance, trees in early stages of hypochnose appear much as do trees affected with the ordinary blight (bacillose), that is, the leaves on numerous twigs throughout the trees are dead. The resemblance is very striking and to the casual observer hypochnose would doubtless pass for the widespread well-known fire blight. Differing from blight, however, the leaves, instead of standing erect, usually droop, hanging down in dense, matted masses. The affection too, is limited to the leaves, the twigs themselves not dying as in the case of the blight.

In later stages of the disease most of the affected leaves fall away and the similarity to bacillose disappears, the tree now attracting attention chiefly by its scant equipment of leaves. Closer inspection of the twigs with the affected leaves shows each to bear two characteristic structures:

1. Roundish or oblong sclerotia usually 1-8 to 1-6 inch in diameter. These are clearly shown natural size on the left-hand branch in figure 20, and somewhat enlarged in figure 21.

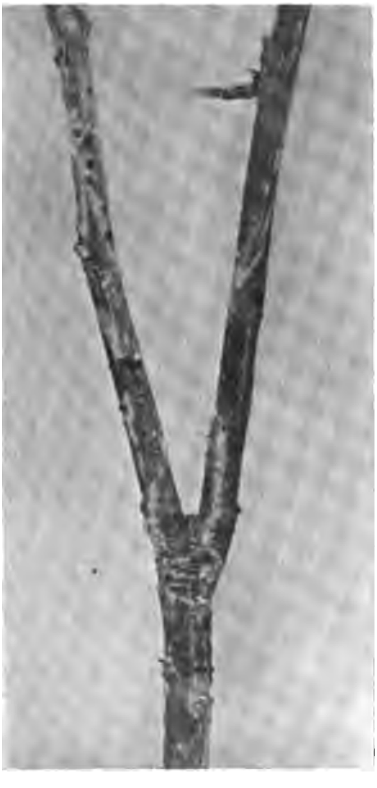


Fig. 20.—Hypochnose sclerotia and mycelial ribbons upon apple twigs. (Natural size.)

2. Mycelial ribbons, extending lengthwise of the twigs and petioles (Figs. 20 and 21).

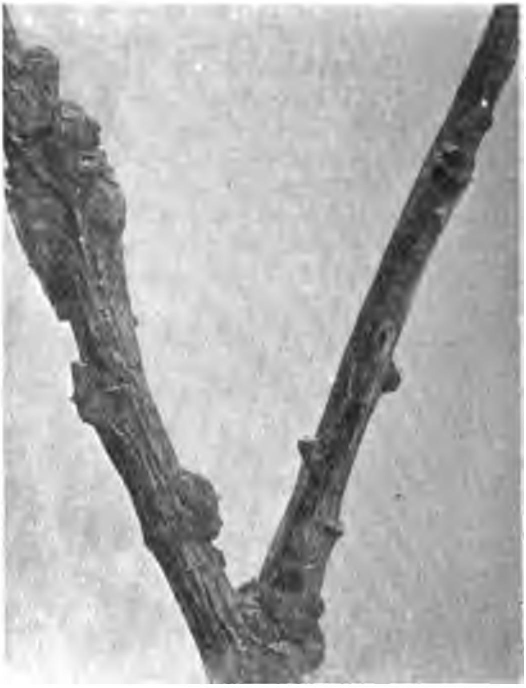


FIG. 21.—Hypochnose sclerotia on apple twigs. (Enlarged.)

These last when young are white, but as they age they rapidly assume a characteristic glistening brown appearance. They extend in a general longitudinal direction, and usually remain unbranched between the nodes, though they sometimes branch and form a network. Occasionally branches diverge to courses leading around the twig. At the base of each small twig the ribbon usually branches, a portion of it passing onto the smaller twig.

Branches of these mycelial ribbons also follow up the stems and the main veins of the leaves, eventually spreading out, separating into single threads and becoming lost to the naked eye. The mycelial ribbons on the older wood die and often weather away, though they adhere with considerable persistence.

Upon the under surface of affected leaves may be found, usually, a more or less dense net of fungous threads. In some instances this weft consists of a dense mat of threads, white or smoky, according to their age (Fig. 22 lower lefthand leaf), in other cases the network may be so sparse as to be imperceptible to the naked eye.

The twigs bearing the fungus do not die from its presence. They seem to be injured only indirectly through the effect of the fungus upon the leaves.

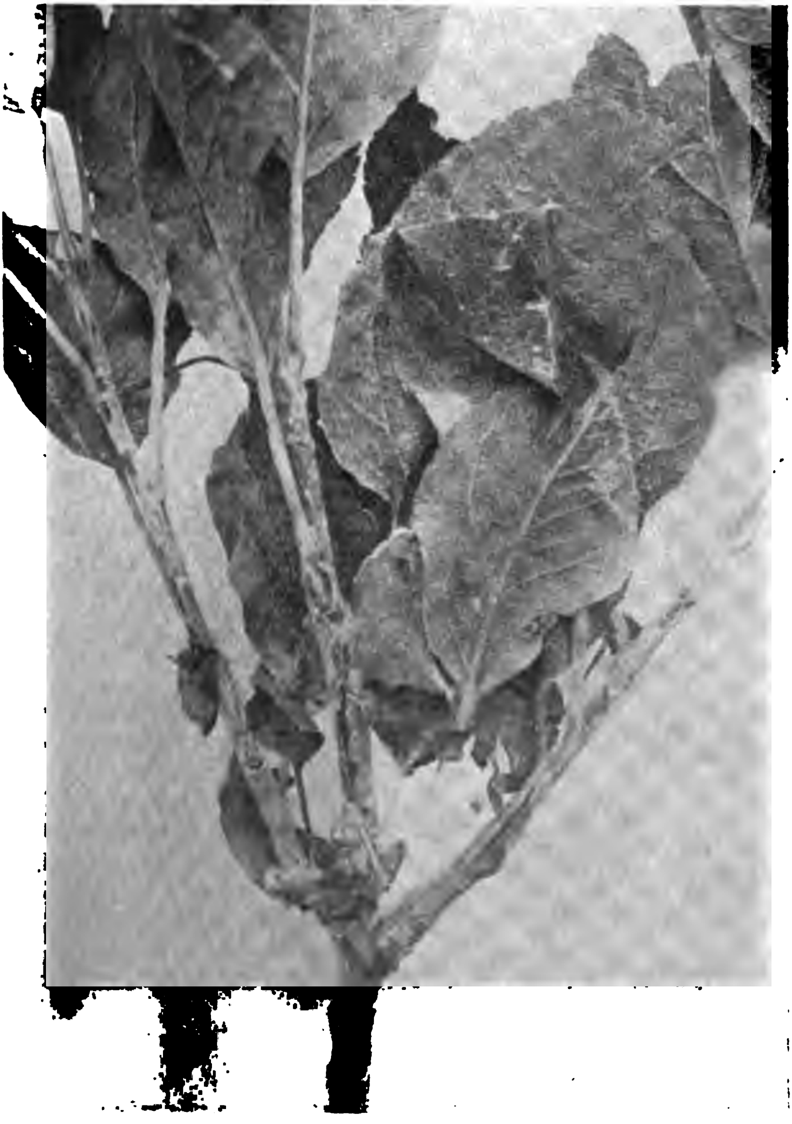


FIG. 22.—Apple twig showing characteristic matting of dead leaves held together by dense growt of mycelium; twigs and leaves densely covered by sclerotia and mycelium.

Leaves bearing the fungus turn brown and die. Since they droop in dying they thus often come in contact with other leaves and the fungus is afforded a ready means of migration to the new victim, which in turn rapidly succumbs. If humid conditions prevail, the fungus grows with great rapidity and vigor between the matted masses of leaves, and fastens the dead leaves somewhat firmly together, thus furnishing one of the distinguishing characteristics of the disease (Fig. 22).

The development of the fungus in early spring has not been studied, but it is clear that the sclerotia are hibernating structures, and that in spring they serve as the initial points for new invasion. The spread of the fungus from point to point is chiefly by means of the ribbon-like structures which serve the purpose so admirably that by mid-summer the uppermost buds are reached and already overlaid by sclerotia ready to carry the invasion on again to another season. The work of the sclerotia is so completely done that rarely, if ever, does the parasite allow the escape of any of the branches originating from a twig upon which the fungus has established itself. Unless saved by outside aid, to be once infected is to be always infected.

In North Carolina this disease has been collected on apple at Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Horseshoe, Bryson City, Fatima, Newton, Eufola, Mt. Airy, Spruce Pine, Rutherfordton, Chimney Rock; on the pear at Slyva; on the quince at Horseshoe. It prevails generally throughout the mountain section of North Carolina, but that it is not limited to the mountains is shown by the fact that specimens with complaints of damage have also been sent to the experiment station from the coastal plain region. Its presence is also known in the mountains of West Virginia and Alabama. The disease occurs with much greater destructiveness in humid localities, such as the mountain valleys where the dew is excessive and morning fogs prevail, and it seems probable that it is of wide distribution where these conditions obtain.

Treatment.—The fungus, wintering in a purely superficial manner upon the twigs and depending to but slight degree upon spores, will probably give way to thorough dormant sprayings. The fact that the disease has not been noted upon sprayed orchards, indicates the efficacy of such treatment.

LEAF SPOTS.

The apple, especially in the western part of the State, is very subject to a leaf spot, the character of which is well shown in Fig. 23. The spots, irregular in outline but roughly circular, are tan colored and dead. The border between healthy and diseased tissue is very definite, and usually the spot bears a series of more or less concentric lines.

Several of these spots upon a leaf largely diminish its starch producing power and thus injure its value to the tree. When badly spotted the diseased leaves fall and almost complete defoliation not infrequently results, with large injury to the yield in succeeding years. This is one of the worst forms of apple disease occuring in the western part of this State.

The spots are of fungous origin, perhaps one, but probably several, species of fungus being responsible for them.

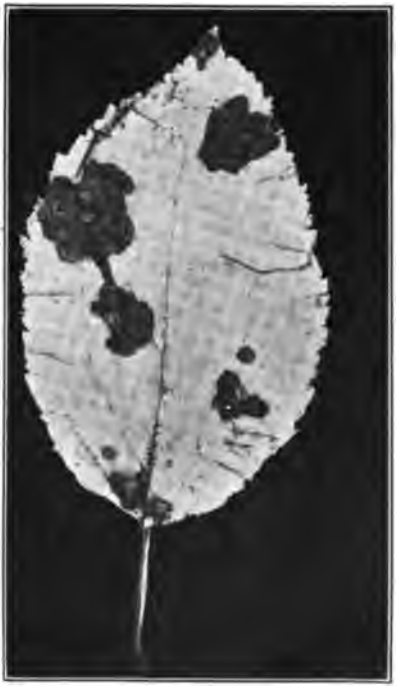


FIG. 23.—Apple leaf spot, in late stage of development, showing concentric rings.

Treatment.—The leaf spot is readily controlled by thorough spraying with Bordeaux mixture, as is recommended for apple scab.

APPLE RUST.

(*Gymnosporangiose*).

The apple rust may be readily recognized by its characteristic yellowish orange spot on the leaves and more rarely upon the fruit. This spot, yellowish green at first, gradually becomes darker, approaching orange. Upon close examination, the upper surface of an old spot is seen to bear numerous black pustules, smaller than a pin-hole, while upon the lower surface of the diseased spot there appear rough, wart-like protuberances (Fig. 24). This spot is sometimes so abundant that its presence upon orchards at great distances may be recognized by the characteristic hue imparted to the foliage mass as a whole. It is needless to say that such rust of the leaf robs the tree of nourishment and renders perfect fruitage impossible.

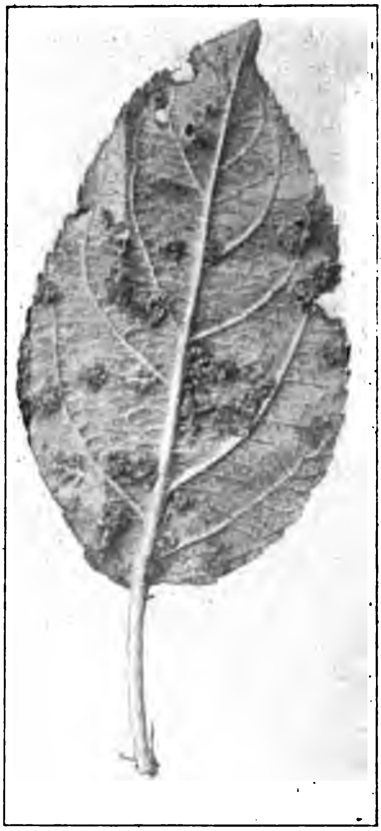


FIG. 24.—An apple leaf affected with apple rust, view from below.

This disease is due to a fungus growing in the leaf, and in this case a peculiar relation similar to that exhibited by the wheat rust obtains, in that the fungus spends part of its life on one plant, the apple, and the remainder upon a totally different plant, namely, the red cedar. The fungus summers upon the apple tree or its near relations, the crab apple, cultivated or wild, and toward the approach of winter spores from the apple trees are carried by the wind to adjacent juniper or red cedar trees. Here the fungus grows and causes what is familiar to every country boy under the name of cedar apple (Fig. 25). The red cedar tree is the *alternate host* of the apple rust.

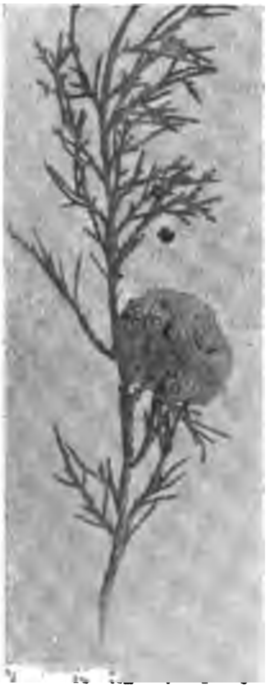


FIG. 25.—Cedar apple, the winter condition of apple rust as it grows upon the cedar tree.

In the spring the cedar apple sends forth gelatinous horn-like projections, each bearing thousands of spores, which, when conveyed by the wind to the apple tree, may cause the apple rust. Evidence that this relation really exists is easily found if one examines an orchard having one or more red cedar trees upon its windward boundary.

There is much difference in susceptibility to this disease among different varieties. Often some varieties of the orchard rust badly while other varieties are entirely free of rust. Winesap, Gano, Ben Davis, York Imperial and Duchess are especially resistent, while Jonathan, Wealthy, Red June and Whiting are susceptible.

Treatment.—It is evident that the more red cedar trees there are in the neighborhood of the orchard, especially to the windward, the more probability there is of damage from the rust. The rational treatment, therefore, is to remove all these trees if possible.

It is known that in rare instances spores may be carried several miles, but orchards may be rendered reasonably secure if all possibility of infection from the immediate neighborhood is cut off. In case the red cedars are too numerous, or if for other reasons it is impossible to cut them, spraying as recommended for the apple scab will probably lessen the evil though spraying, for this disease gives rather uncertain results.

BITTER OR RIPE ROT.

(*Glomerellose*).

This rot, as its name implies, imparts a bitter taste to the apple in the region of the decay. It is found abundantly upon the ripe fruit, although by no means limited to such.

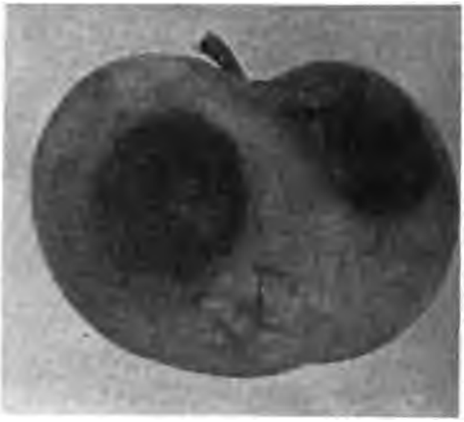


FIG. 26.—Apple ripe rot. Note spore-bearing pustules, especially abundant near the center of the spot.

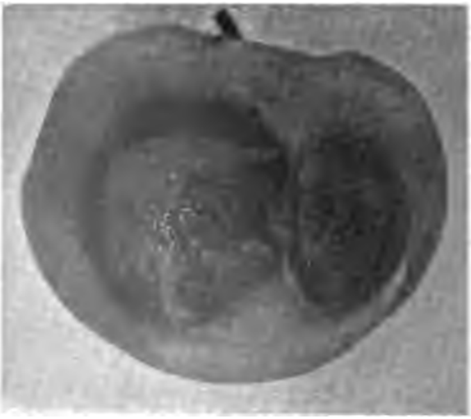


FIG. 27.—Apple ripe rot: somewhat later stage than Fig. 26.

The decayed spots may occur either singly or in considerable number on the apple, and if watched from day to day they may be seen to enlarge rapidly, spreading from the center outwards, thus maintaining a circular form (Fig. 26). As the spot enlarges, small pustules, usually arranged in concentric lines (Fig. 27), appear near the center. As these pustules grow older, they break and assume a pinkish hue, which is quite characteristic of this disease. The rot gradually advances until the whole apple becomes involved, it being changed into a shrunken, worthless mass (Fig. 28).

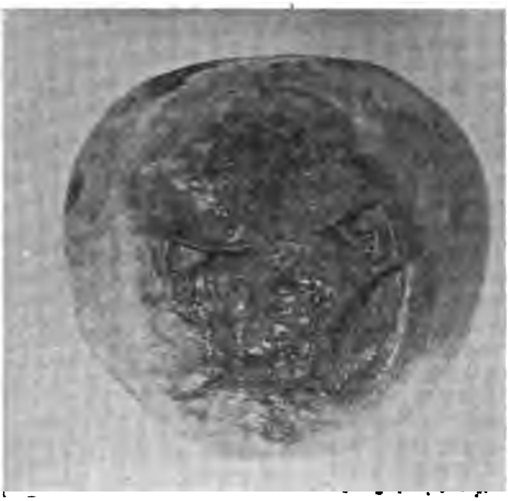


FIG. 28.—Advanced stage of ripe rot.

This disease is of fungous origin. Spores fall upon the surface of the apple, germinate, and penetrating the skin, develop a mycelium in the underlying tissue. The small pustules seen on the surface of the decayed spots are clusters of spores which may be washed off by the first rain, to infect new fruit. That the disease is contagious can readily be proved by inserting a few of these spores under the skin of the healthy apple which will then decay rapidly. Warm, wet weather favors the disease.

This disease is particularly prevalent in the South and has long been of serious damage in North Carolina, although we have no accurate estimate as to the exact injury done. It has been noted in very destructive form in the piedmont and mountain sections, and in many instances is responsible for the failure of the apple crop in these regions. In many cases the entire crop is lost through its ravages. In the State of Illinois in 1900, it was estimated that $1,500,000 worth of fruit was destroyed upon the trees in four counties alone. Professor Burrill says, "There is no other disease that is so enormously destructive to the apple fruit as the one commonly called the bitter rot."

In 1902, R. S. Simpson and T. J. Burrill, of Illinois, and H. Von Schrenk and Perley Spaulding, of the U. S. Department of Agriculture, independently proved that the same fungus that causes the bitter rot also causes what may be known as the *bitter rot canker* on apple tree twigs.

The bitter rot canker which often starts from a bruise, consists of a sunken bark wound, from two to four inches long, with a ragged border. It is usually found on limbs a half an inch in diameter or larger, though it sometimes grows on smaller twigs. The attack seems to be limited to the bark, as the wood is not injured. Careful inoculations have proved that the spores taken from the bitter rot of the apple cause the canker of the twig, and that spores taken from the canker cause the bitter rot of the fruit. Moreover, in the orchards it is noticeable that early in the season apples suffering from the bitter rot are usually affected first on their upper surface, and that above such affected apples we may often find the apple canker. Indeed, there seems to be complete proof that the infection of each season starts with the canker, the spores being washed down by rain to the apples below. It thus happens that the diseased apples of a given portion of a tree are often arranged in the form of a cone, and that at the apex of this cone is a bitter rot canker, the initial source of infection.

Treatment.—It follows from the relations existing between the apple canker and the bitter rot of the fruit that the same treatment should be employed for each, and that the prevention of the canker means also the prevention of the rot. The orchard should be carefully and systematically inspected and all cankers removed, thus doing away with the source of infection. In addition to this, great care should be exercised at time of pruning and picking, to avoid bruising the bark of the twigs and thus to a great extent prevent the development of the canker on the tree. It is advisable to apply copper sulphate, 1 pound to 18 gallons of water, to the twigs and branches in winter, and to spray as is recommended for apple scab, placing especial emphasis, however, upon that late spraying when the fruit is quarter to half-grown, and substituting ammoniacal copper carbonate or Burgundy mixture for the last spraying in order to avoid spotting the fruit.

BLOTCH.

(*Phyllostictose*).

The blotch, while seriously destructive in some sections of the United States, has not yet injured the fruit in North Carolina to any appreciable extent, though it occurs in abundance upon the twigs producing small bark cankers. These however have not as yet been injurious.

The presence of the disease upon the twigs may result in an outbreak of the more serious fruit disease at any time that climatic conditions become favorable to the growth of the fungus.

Upon the fruit this disease may be recognized as dark colored spots of very irregular fringed, jagged outline (Fig. 29), a half inch or less in diameter. When seriously affected the apple cracks, the cracks reaching even to the core. Minute black pycnidia may be noted in the center of the older spots.

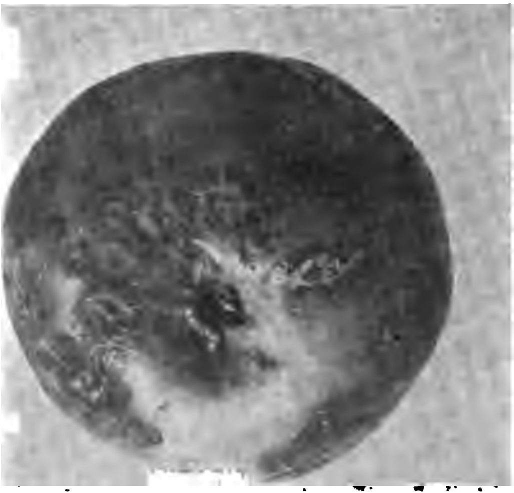


FIG. 29.—Apple blotch. Note irregular boundary of the diseased spots.

Upon the youngest twigs small tan colored dead spots in the bark appear. These bear numerous small pycnidia. These bark spots are very sharply bordered and are readily recognized from Fig. 30. As the twigs thus affected grow older the spots enlarge to superficial cankers, often several inches long; areas with the bark rough and flaking off.

Treatment.—Four applications of Bordeaux mixture, the first, three to four weeks after the petals fall; the second, four weeks later; the third and fourth, at intervals of three weeks thereafter, are usually sufficient to control the disease. Cankered twigs should be removed and burned.

OTHER CANKERS.

There are several other types of bark wound or diseases which are grouped under the general term of canker. These all have a general resemblance to the bitter rot canker, yet show slight specific

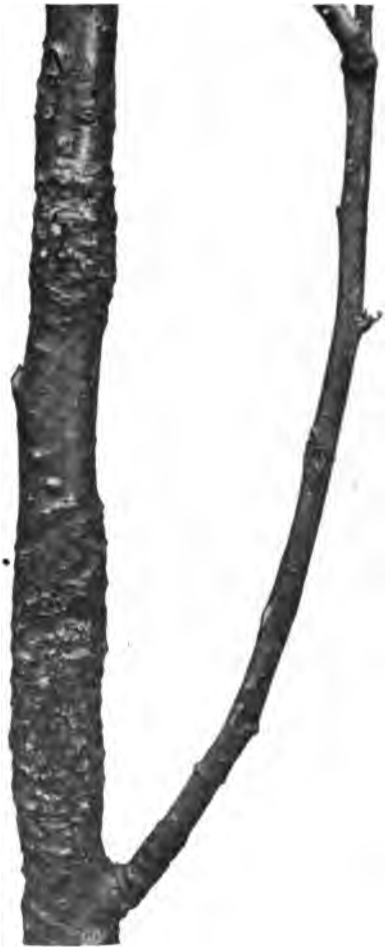


FIG. 30.—Apple blotch canker: at right one year-old twig showing several young cankers: at left, older twig showing more mature, rougher canker.

differences. The injury is at first local, but frequently results later in the death of the affected limb.

Treatment.—As these are caused by fungi which enter through a bruise or injury, three preventive measures are suggested:

1. Destroy cankered limbs to reduce the sources of infection.
2. Avoid bruises and wounds of all kinds.
3. Spray with Bordeaux to prevent germination of spores.

BLACK ROT.

(*Sphaeropsose.*)

This disease of the apple looks very much like the bitter rot, so much like it, indeed, that it would be impossible to distinguish one from the other in an illustration. However, the black rot possesses a prevailing blackish hue, while the bitter rot, though rarely black, is commonly reddish or pinkish. The spore pustules of the black rot are black, while in the bitter rot they are pink. In other details the two rots closely resemble each other. The black rot is abundant on green apples which frequently fall owing to its attack. Sometimes also it is serious on ripe apples and on fruit in market. The fungus which causes this disease, like the bitter rot, also causes a canker on the bark of twigs.

Treatment.—Methods of eradication should look to elimination of the canker, and spread of the disease should be checked by the use of the Bordeaux mixture.

SOFT ROTS.

There are numerous kinds of soft rots which affect ripe apples in the bin. These are all due to fungi, which effect an entrance into the apple through bruises or breaks in the skin. Once inside the skin, the fungi grow rapidly throughout the fruit, converting it into an impalatable, disagreeable mass. The fungus then proceeds to spore formation, and apples in the latter condition of decay are covered with veritable forests of fungous hyphæ laden with spores. If a healthy apple lies in contact with such an affected apple, it also will succumb.

Treatment.—Very little can be said regarding the protection of fruit from these soft rots, other than to emphasize the need of care to preserve the skin of the apple in sound condition, since bruises or cuts render the entrance of the fungus possible. Cold storage retards the growth of the fungi.

POWDERY MILDEW.

(*Podosphaerose.*)

The powdery mildew is a disease of apples which is of most injury to nursery stock, often becoming so serious as to prohibit successful budding. The use of the ammoniacal solution of copper carbonate as the leaves unfold, and continued at intervals of two weeks until budding time, will effectively prevent this disease.

APPLE SCURF.

(*Phyllostictose*).

This disease was first described in the Thirtieth Annual Report of this Station. It has been under observation for several years, and has been sent to the station with inquiries from two different sections of the State.

The first specimen was received from Watauga County, N. C., in May, 1905. The chief symptom is a shrinking of the bark, including the epidermis, in such manner that minute air spaces are left immediately below the cuticle, giving to the affected region a silvery gray appearance. Close examination, especially with the aid of a lens, shows the presence of myriads of minute black pycnidia scattered throughout the affected region. Such a condition may extend over large areas on twigs one, two or three years of age. The seriousness of the disease, the amount of damage done, is unknown. That the condition has attracted the attention of practical apple growers to sufficient extent to cause them to submit specimens for diagnosis indicates that the injury is at least appreciable to the apple growers of the State. Death of the infected twigs does not always seem to follow infection. The disease is limited to the bark, and is, therefore, slow to cause death.

Treatment.—Spraying and close pruning of affected branches will probably lead to control of this disease.

BROWN ROT.

(*Sclerotiniose*).

The brown rot upon the fruit, while serious in Europe, has not been destructive in North Carolina, though it has been seen in a few orchards.

The diseased spot turns tan colored, becomes soft and rotten. As the spot ages it becomes coated with a brown fuzzy coat (Fig. 31) similar to that so often seen upon rotting plums or cherries.

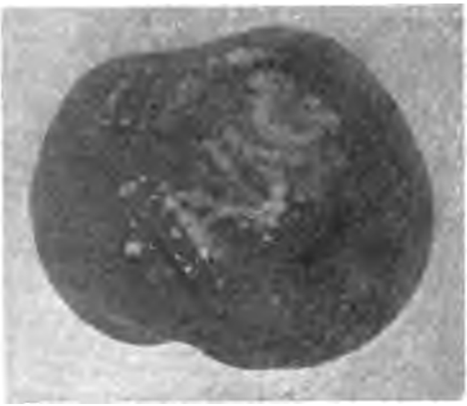


FIG. 31.—Apple brown mould (sclerotiniose). This rot was produced by inoculation. Note that the mould appears forming the letters A. M. C.

No treatment seems necessary. Diseased fruits should be fed to stock to prevent infection in succeeding years.

VOLUTELLA ROT.

(*Volutellose*).

A black rot of apples, closely imitating in appearance that caused by *Spaeropsis,* but differing from sphaeropsose in several details, has been observed frequently in various sections of this State on native apples and on apples shipped into the State.

In general appearance the disease consists of a rotten black spot, the spot increasing in size until it eventually encompasses the whole fruit. The central and older portions of the decayed region are of an intense coal black color. The younger region of the spot, its outer border, a zone about five-eights of an inch wide, is brownish.

Close inspection reveals the presence of slightly elevated pimple-like places in the skin. These are found within about one-fourth of an inch of the edge of the spot, and are larger and more pronounced near the center of the spot, indeed the black color of the spot seems to be due to the thick setting of these black pimples all over its surface. In many instances, unless the spot be quite old, no other development is seen and the disease might readily be mistaken for the ordinary black rot, sphaeropsose, and doubtless often passes for it. In older spots, however, the pimples break through the cuticle of the apple and each pimple appears as a small wart-like excrescence. A good lens then shows that it is thickly set with stiff black hairs. These hairs constitute the distinctive character of this disease and serve to separate it with ease and certainty from sphaeropsose.

On slicing the apple open it is seen that the zone most recently invaded is brownish, while all of the older portion is black (Fig. 32).

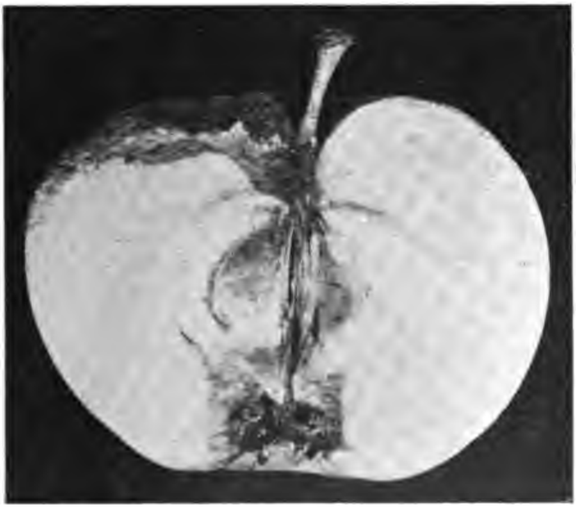


FIG. 32.—Volutella rot in section.

While the decayed portions are softer than the healthy, this is in no sense a wet rot, the softness being due to a spongy dryness rather than to any watery breaking down of tissue. Upon microscopic examination the cells of the old, dark, diseased portion of the apple are found to be filled with a tangled mass of black or dark brown fungous threads (Fig. 33) which are richly septate and much branched.

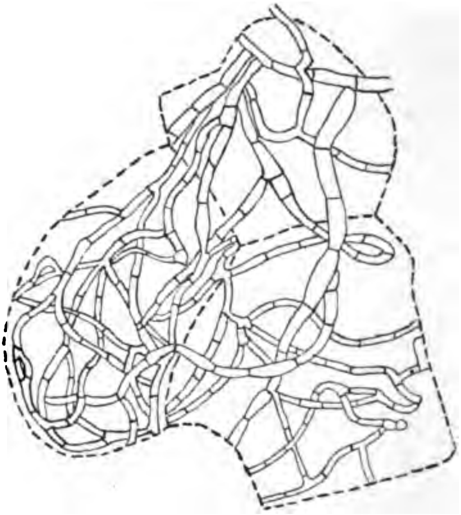


Fig. 33.—Cell invaded by mycelium.

As the spot ages the mycelium develops more abundantly in a few layers of cells immediately under the cuticle (Fig. 34). From

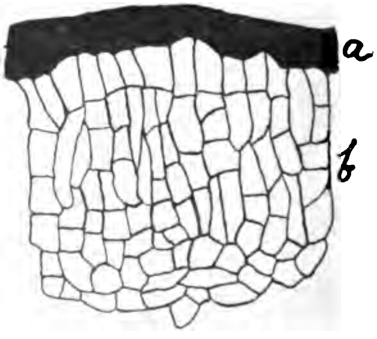


Fig. 34.—Palisade arrangement of hyphæ.

this layer of tangled mycelium there develops a cushion of hyphæ, and from these the sporodochium, characteristic of the fungus (Fig. 35). In these the spores are borne.

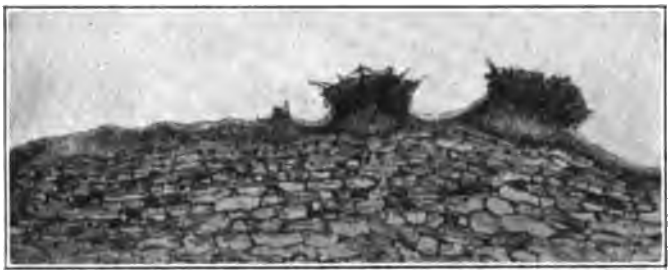


FIG. 35.—Sporodochia in section.

Treatment.—It is probable that the sprayings usually recommended for scab and black rot will be effective in controlling this rot.

FRUIT ROT.

(*Coniothyriose*).

The rotten spot is circular in uniform tissue, brownish, about the color of the common soft rot, and due to loss from evaporation, the tissue shrinks as the spot ages, leaving the surface much wrinkled (Fig. 36). Distributed somewhat sparsely and irregularly over the spot are the fruiting cavities of the fungus (pycnidia). In rotten spots, produced by inoculation, the pycnidia frequently assume a

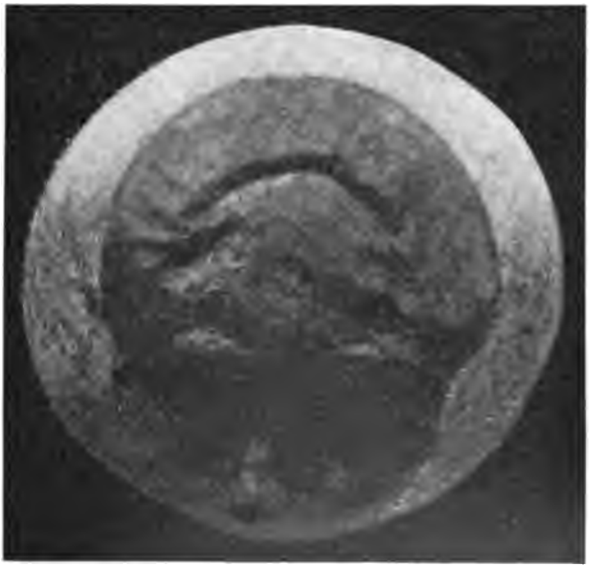


FIG. 36.—Coniothyrium rot.

somewhat concentric arrangement. Proceeding from the innermost pycnidia toward the edge of the spot the pycnidia become smaller, none at all being found near the edge of the diseased tissue.

Upon sectioning through a diseased spot the flesh of the fruit is seen to be rotten, brownish and soft (Fig. 37), not black or dry, as is the case with the volutella rot.

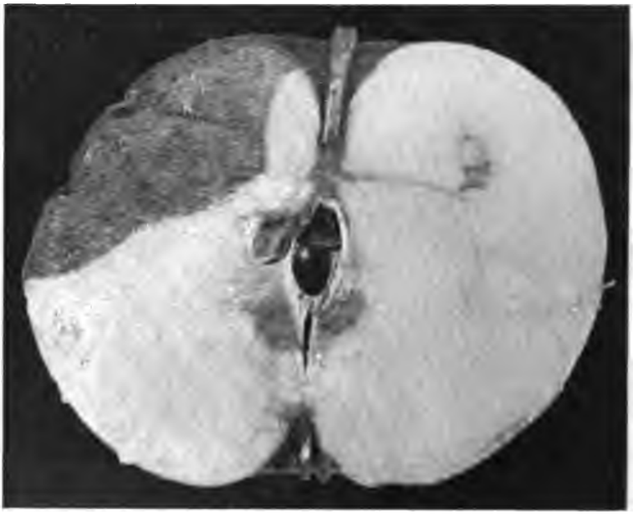


FIG. 37.—Coniothyrium rot in section.

Microscopic examination shows the diseased tissue to be thoroughly invaded with a thin branching mycelium.

When this disease is upon twigs, the terminal portions of recent growth die, the bark shrinks and shrivels, turns black and at the line of demarkation between diseased and healthy tissue cracks (Fig. 38). The general appearance of such a twig is much like that caused by the fire blight, but is readily distinguished by the presence of very numerous, minute, pimple-like pustules, the pycnidia, distributed over the dead part.

The significance of this fungus upon twigs is twofold: (1) As a cause of the twig blight; (2) as a source of infective material, spores, to transmit the rot to the fruit.

Treatment.—Spraying coupled with careful pruning out and burning of diseased twigs and branches will doubtless serve as a means of control of this rot, both of branches and fruit.

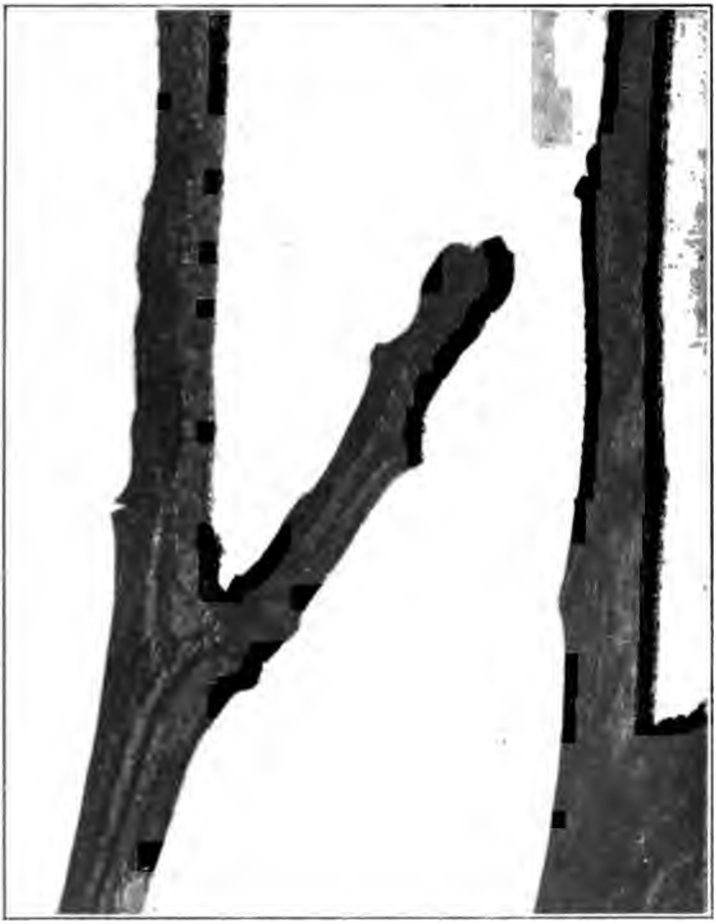


FIG. 38.—Coniothyriose of twigs.

FLY SPECK.

(*Leptothyriose*).

This is well illustrated in Fig. 39.

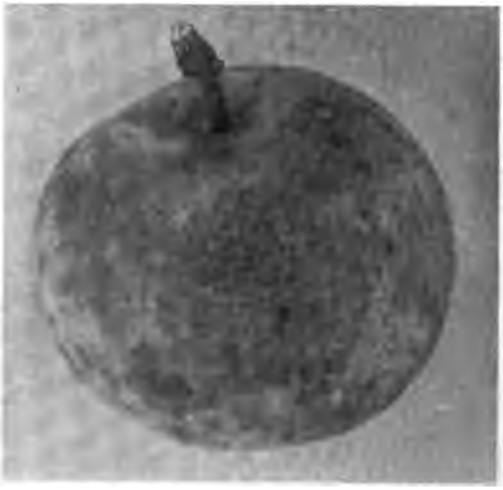


FIG. 39.—Apple fly speck. A superficial fungus of minor importance.

The disease is prevented by the combined spraying given below.

1.—COMBINED TREATMENT FOR APPLE DISEASES.

1. Use all care to avoid bruising bark or breaking the limbs and thus opening the way to canker causing fungi.
2. Use clean culture. Clean up and burn all diseased parts, leaves, fruit, twigs, etc., to lessen infection the succeeding year.
3. Inspect the trees carefully for cankers and blighted parts of any kind; cut them out and burn them to diminish infection.
4. If diseases that winter upon the bark (hyphocnose, etc.) are present, use a dormant spray, Bordeaux mixture, blue stone, or a lime-sulphur wash.
5. Beware of the proximity of cedar trees.
6. Employ spraying mixtures. Bordeaux mixtures 4-4-50 for the earlier sprayings; ammoniacal copper carbonate or Burgundy mixture for the latter sprayings when spotting of the fruit is to be avoided. Spray thoroughly with proper regard for weather conditions.

Spray:
1st. Before the blossoms open.
2d. Immediately after the blossoms fall.
3d. About three to four weeks later.
4th. About four weeks later.
5th. About three weeks later.
6th. About three weeks later.

2.—FUNGOUS DISEASES OF THE PEAR.

BLIGHT.

(*Bacillose*).

The affected tree with its shriveled branches and shrunken, blackened twigs gives the impression of injury by fire. In many cases

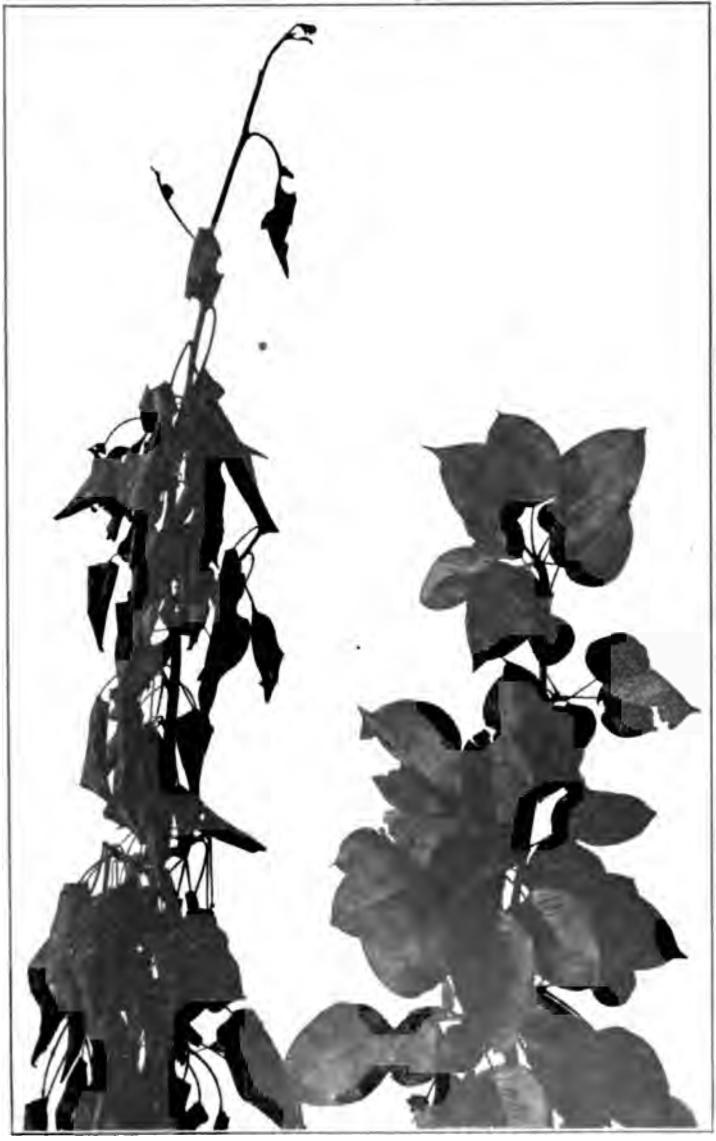


FIG. 40.—Pear blight. a, healthy twig; b, characteristically diseased twig.

even whole orchards have succumbed. One pear grower near Washington, D. C., estimated his damage from this one disease in one year at $10,000. The disease is widely known and is present in every county of this State.

During winter the disease may best be recognized by the fact that the leaves of the diseased twigs do not fall as do those of the healthy twigs. In the early spring, when the disease is most aggressive, the blighted twigs are known at a glance by their shriveled, darkened leaves, while on closer examination the black bark attests clearly to the presence of the blight.

This disease has been known since 1780, and affects the apple, quince, hawthorn and plum as well as the pear. It appears sometimes as twig blight, and at other times as flower blight.

Many theories as to the nature or cause of blight have been advanced, among which might be mentioned those depending upon electrical or atmosphere influences, freezing of the bark, too long culture of particular varieties, freezing of the roots, too high culture. insects, absence of needed food and fungi. One of the most prominent among these, put forward by the well-known apple expert, Downing, was known as the "frozen sap theory," according to which the disease was due to the freezing and thawing of the sap, resulting in a loss of vitality and a development of poisons in the tissues. It is unnecessary to discuss any of those theories further than to say that by none of them could all the facts be explained.

In 1878, Burrill discovered in the diseased twig many minute living germs, bacteria. He transferred wood and bark from diseased twigs bearing these germs into healthy twigs and found that the blight was also transferred. Arthur later cultivated the germs for several generations in nourishing substance and then inoculated them into healthy trees and produced the disease. The fact now seems clearly established that it is these bacteria that cause the blight.

We must realize that the bacteria are only about one twenty-five thousandth of an inch long. They grow in the juicy succulent twigs, particularly in the cambium, that juicy part of the stem lying between the bark and the wood. They have no independent means of passing from tree to tree and for transportation are almost entirely dependent upon insect visitors which frequent the diseased twigs in order to secure a sweetish solution which exudes from their surface in drops. These drops are teeming with bacteria, and the insect visitors carry on their feet thousands, even millions, of them which infect the next tree visited. By insects the disease is often conveyed to the blossom, which being an especially succulent and tender portion, furnishes ready access as well as suitable conditions for the development of the germs.

It thus happens that the disease spreads rapidly, doing most damage in spring, owing both to the prevalence then of the succulent stems and branches and to the more ready insect transportation.

It is a matter of common observation among pear growers that trees in too rich soil are more susceptible. This is entirely explainable from the fact that such soil produces a greater amount of succulent, rapidly growing shoots. So too any cause, such as too much pruning, too high fertilization or cultivation, or anything tending to promote too rapid growth, favors the blight. Such conditions are to be avoided, thus lessening the liability to infection; yet this advice must not lead too far, or the tree will suffer from maladies other than the blight.

The proper way to eradicate the blight is to remove the source of infection. To do this, one must remove from the vicinity all infected wood, must cut out and burn all diseased twigs, leaves or branches, either on the pear, apple, quince, hawthorn, plum, or related trees, which might otherwise furnish bacteria for the insects to carry to other trees. If this be done, and done thoroughly, the disease can be controlled. A prominent fruit grower said recently that no man with a sharp knife need fear the blight.

The proper time to cut is whenever affected branches are seen. In the early spring when the diseased foliage is especially easy to recognize, is a favorable time. Subsequent inspection should be made weekly and all blight that is found should be removed. It is well to cut at least a foot below the affected region, since all germs must be removed to secure safety. The greater part of the blight will be removed without difficulty by one thorough fall and spring pruning, but this is useless unless followed up by careful weekly pruning throughout the summer.

Whenever limbs are cut off or bruises made, it is necessary to cover the wound with paint, grafting wax or some other compound (see page 90), to prevent the access of rot-causing fungi and blight bacteria.

If the pruning knife at any time cuts into the diseased wood, it will become smeared with germs. These should be killed by dipping the knife into carbolic acid or corrosive sublimate solutions (1 part to 1000) before cutting again into healthy wood.

ANTHRACNOSE.

(*Colletotrichose*).

This disease was first seen in 1892 by the writer on a pear tree in New Jersey, where it destroyed nearly every fruit on the tree. It is very serious, but fortunately not of frequent occurrence. It has not yet been recorded in this State. In nature, cause and appearance, it closely resembles the ripe rot of the apple (glomerellose), and the treatment is the same as for that disease.

PEAR RUST.

(*Gymnosporangiose*).

The rust of the pear is very similar in nature to the rust on the apple which has been discussed on another page in this bulletin. It consists of two stages, a summer stage and a winter stage. The summer stage produces the rust on the leaves of the pear, while the winter stage forms the familiar cedar apple.

The remedy, as in the case of the apple, consists in removing all cedar trees from the neighborhood of the pear orchard, thus eliminating the source of infection. When this is impossible, the pear trees should be sprayed with the Bordeaux mixture immediately after the early rains which cause the gelatinous horns on the cedar apple.

This disease of pears is particularly abundant upon varieties of the Japanese strain.

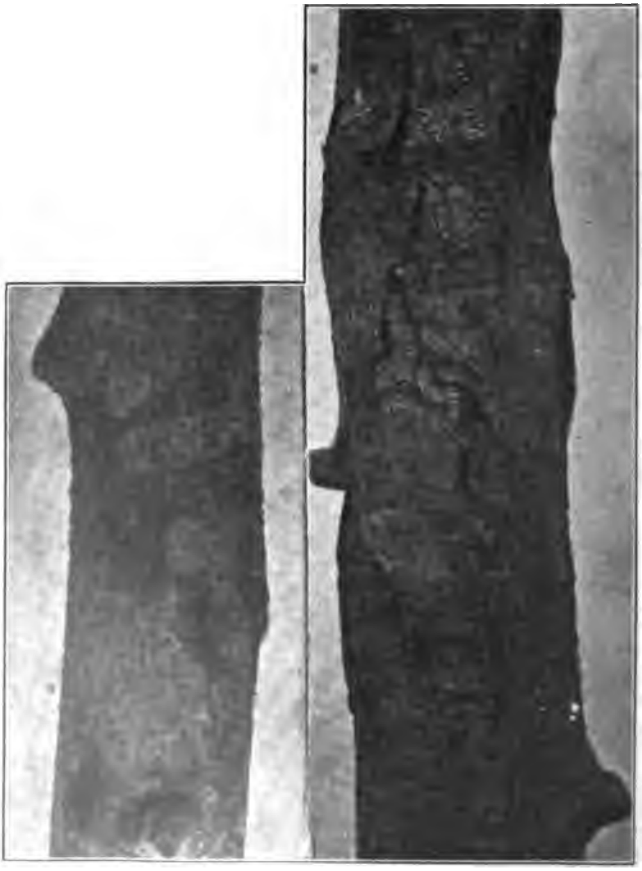


FIG. 41.—Pear canker (sphaeropsis). At right the cracked bark of cankered portion. Minute spore-bearing pustules are apparent in certain portions. At left, bark thickly beset with spore-bearing pustules.

PEAR CANKER.

There is a canker (Fig. 41) on the pear closely related to the cankers previously described for the apple. That they are of fungous origin has been proved by many inoculations.

It is probable that spraying the bark with Bordeaux mixture will partially or wholly eradicate this enemy, although no conclusive experiments seem to have been made on this subject.

PEAR SCAB.

(*Venturiose*).

The pear scab is familiar to all who raise the pear. It consists of a surface blotch or scab (Fig. 42), often accompanied by a peculiar cracking. This, however, is an effect which is present only in advanced stages of the disease.

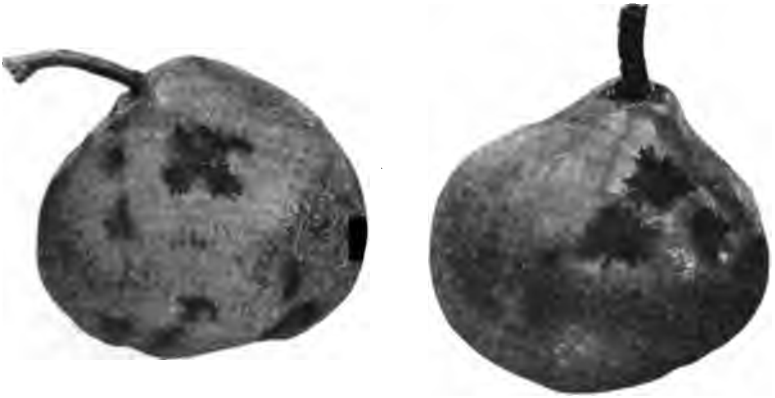


Fig. 42.—Pear scab.

The pear scab is caused by a fungus very similar to that which causes the scab on the apple. Fig 43 shows its microscopic structure.

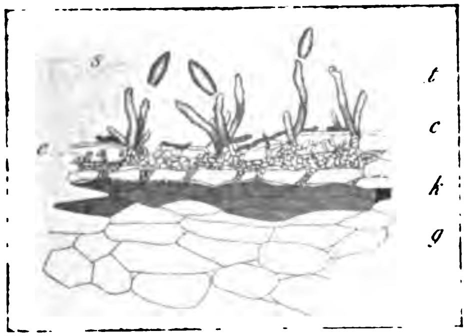


Fig. 43.—The hyphæ of the pear scab fungus-bearing spores.—After Duggar.

The black stalks sticking above the surface are the branches of the fungus, which are to bear the spores, and the three roundish or oval bodies are spores which have just separated from their place of origin. The threads or mycelium of the fungus lie below the skin (*c*) and there take up nourishment, and cause discoloration.

The fungus passes the winter on the bark, as well as upon the diseased fruit and leaves.

Treatment.—This disease has proved amenable to treatment. Results from the Vermont Station show benefit in both quantity and quality from spraying with the Bordeaux mixture, the market value of the fruit being increased from twenty-five to fifty per cent, for example, in case of the Flemish Beauty. In some cases the value of the sprayed crop being placed at one hundred, the crop which was not sprayed brought a value of only forty-seven.

The treatment for prevention consists in spraying to kill the spores and to prevent the development of the fungus. The first spraying should be made before the leaves open, and should consist of copper-sulphate one pound and water eighteen gallons. The Bordeaux mixture should then be used three times: First, just before the blooms open; second, just after the flowers fall, even before all have fallen; third, about two weeks later. The Bordeaux mixture should be of the usual strength, four pounds of copper sulphate, four pounds of lime and fifty gallons of water.

LEAF SPOT.

(*Septoriose*).

The leaf spot, while never completely destructive to foliage or crop, does interfere with the general productiveness and health of the tree by diminishing its green surface. Leaf spot may be distinguished from scab and blight by the fact that the diseased areas are rather sharply defined and characteristically angular in outline Fig. 44). .The center of the spot, usually of an ashen color, is surrounded by a brown zone, and this in turn by a purplish one. The ashen center bears several exceedingly minute dark-colored pustules. One of these in section is shown in Fig. 45. The pustule is really a hollow structure bearing numerous worm-shaped spores. Each spore that finds favorable lodgment upon another leaf, is capable of producing the disease.

Treatment.—The treatment recommended for the pear scab is effective in preventing this disease.

LEAF BLIGHT.

(*Fabræose*).

The leaf blight of the pear is almost as widely distributed as is the pear itself. The spot caused by the leaf blight does not exhibit the zonal arrangement described for the leaf spot, and the whole

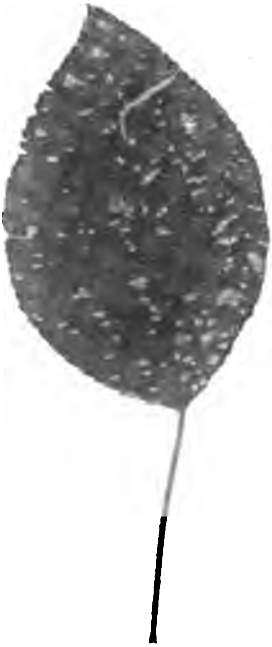


FIG. 44.—Pear leaf spot, septoriose.

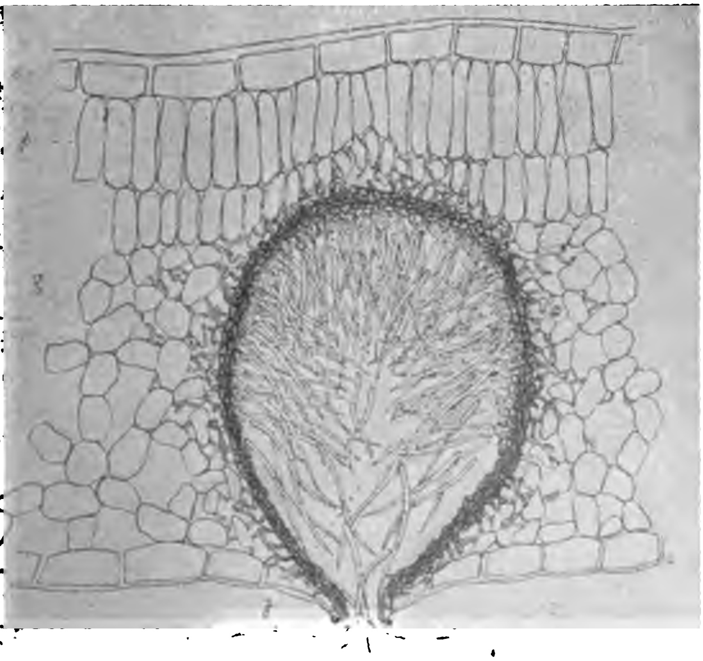


FIG. 45.—Section of a pear leaf showing the leaf spot fungus and its spores.—After Duggar.

leaf more often takes on a diseased appearance, eventually turning yellow or brown and falling. This disease also prevails upon the fruit where it causes a red spot. This soon becomes darker, and may later be accompanied by cracking similar to that of the pear scab. The spores are produced in the centers of the diseased spots, and differ decidedly from the spores of the fungi of the other pear diseases as may be seen in Fig. 46.

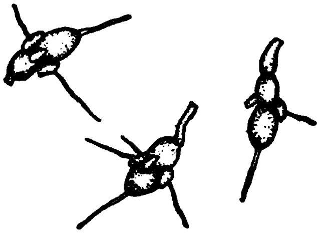


FIG. 46.—Spores of the leaf blight fungus.—After Duggar.

Treatment.—The treatment already recommended for the pear scab will suffice for the pear leaf blight.

HYPOCHNOSE.

This disease, identical with hypochnose of the apple, occurs occasionally upon the pear. The treatment given on page 94 is effective.

3.—FUNGICIDES.

Many plant diseases are caused by fungi, which gain entrance to the plant at the surface by means of reproductive bodies called spores. A fungicide is a mixture which is sprayed upon the surface of the plant, and which by its poisonous properties prevents the spores from successfully germinating and entering the plant.

Spraying for fungous diseases is recognized, by the successful horticulturist as a necessary measure.

BORDEAUX MIXTURE.

This mixture, which takes its name from its place of discovery, Bordeaux, France, is the most widely used and with certain limitations the most effective fungicide. It consists of copper sulphate (blue vitrol or blue stone) and quick lime mixed with water in various proportions.

The chief strengths of Bordeaux mixture are as follows:

4-4-50 BORDEAUX.

Copper sulphate or blue stone	4 pounds.
Quick lime	4 pounds.
Water ..	50 gallons.

This strength may be used on most plants, the foliage of which is not susceptible to injury.

This formula is recommended for apple, pear and quince.

6-4-50 BORDEAUX.

Copper sulphate or blue stone	6 pounds.
Quick lime	4 pounds.
Water ..	50 gallons.

This second strength is particularly for dormant trees.

Plants with delicate foliage such as the peach, plum, cherry and apricot require weaker solutions, for example:

2-2-50 BORDEAUX.

Copper sulphate	2 pounds.
Quick lime	2 pounds.
Water ..	50 gallons.

Or—

2½-6-50 BORDEAUX.

Copper sulphate	2 1-2 pounds.
Quick lime	6 pounds.
Water ..	50 gallons.

There is no certainty as to which of these strengths is best. To many crops no damage can come from the use of as strong a solution as 6-4-50, yet it is possible that all the protection possible is to be had by use of the 4-4-50 mixture or even by a weaker mixture. If so, there is loss of material by use of the stronger solution. This matter is still open to experimentation.

In the preparation of the Bordeaux mixture, it is well to have on hand stock solutions of copper sulphate and lime. The stock solution of copper sulphate should be made by dissolving a certain number of pounds of copper sulphate in one-half the number of gallons of water, for example: 80 pounds copper sulphate in 40 gallons of water. It is then known that each gallon of this stock solution contains two pounds of copper sulphate, and necessity of further weighing is avoided. The stock solution remains good for any length of time if the water evaporated is replaced. In order to dissolve the copper sulphate, it is best to tie it in a coarse bag and suspend it near the top of the water in a barrel. In this way it will dissolve in a few hours. If it is placed in the bottom of a barrel it will dissolve but slowly, even with constant stirring. It is well to suspend the copper sulphate the night before the mixture is to be made, and it will then be ready in the morning.

In a similar way a stock solution of lime should be made. Quick lime of good quality, which is not at all air-slaked, should be weighed out and placed in a trough and slaked slowly, using a very small quantity of water. By slaking slowly a fine quality of lime is secured. After the lime is thoroughly slacked it should be mixed with enough water to make a putty-like mass. This may be covered with more water to keep out the air and may be used when needed. Since this mass was originally weighed one can estimate near enough the amount needed for any given quantity of Bordeaux mixture.

In preparing the Bordeaux mixture from stock solutions, measure out the proper amount of stock solution of copper sulphate and dilute it with half the amount of water needed in the final mixture. In a similar way measure out the proper amount of lime needed from the stock and dilute it with the other half of the water in a separate vessel.

The lime should be passed through a fine wire strainer of about eighteen meshes to the inch, or through cheese cloth, in order to remove particles of stone, which will otherwise cause difficulty in the nozzle when spraying.

All that remains is to mix these two solutions. They should be poured together slowly and thoroughly stirred.

It is a matter of considerable importance that the stock solutions be diluted before they are mixed with each other. The quality of Bordeaux mixture resulting from this method is superior in several respects to that which results if strong solutions are mixed together and afterwards diluted.

The Bordeaux should be freshly made each time before using.

SODA OR POTASH BORDEAUX MIXTURE.

While the Bordeaux mixture is eminently successful in preventing many plant diseases, slight difficulty is sometimes encountered owing to the occurrence of small stones, resulting from imperfections in the lime. These, if not thoroughly strained out, clog the spraying nozzle and are troublesome. To escape this difficulty and to render the preparation and application of the Bordeaux mixture easier, as well as to give a mixture suitable for use as the fruit approaches maturity, the use of potash or soda as substitutes for the lime has been recommended.

SODA BORDEAUX.

Copper sulphate (blue stone)	5 pounds.
Commercial caustic soda sufficient to combine with copper sulphate and leave a slight excess of soda	.... pounds.
Water	50 gallons.

It will be noted that the amount of caustic soda to be used is not stated definitely. It is impossible to make a definite statement, as the strength of the various commercial sodas varies greatly.

The following table, however, gives the amount of copper sulphate required for a single can of several of the more common sodas. In the last column is found the amount of mixture which a can will make. For example, if you choose to use the Champion soda, a can of which weighs 13.73 ounces, you should use 1.6 pounds of copper sulphate to each can of soda. One can of soda contains 12 ounces of substance and the 1.6 pounds of copper sulphate together with the one can of Champion soda will make thirteen gallons of soda Bordeaux.

In a similar way, by consulting the table you may find how much copper sulphate to use per can with any of these brands and how much mixture it will make.

	Gross Weight of Can.	Weight of Substance,	Copper Sulfate Required.	Amount of Mixture.
Soda (Troy)	11.2 lbs.	10.17 lbs.	46.22 lbs.	462 gals.
Babbitt's Potash	17 oz.	14.5 oz.	3 "	30 "
Champion	13.75 "	12 "	1.6 "	16 "
Red Seal	17 "	14.5 "	2.4 "	24 "
Leggett's	17 "	14.75 "	2.5 "	25 "
Lehman's	14.75 "	12.25 "	2.4 "	24 "
Hirsh	14.5 "	12.75 "	1.8 "	18 "
Washington	14.25 "	12.75 "	1.7 "	17 "
Saponifier (Solid)	15.75 "	14.25 "	2.5 "	25 "
Saponifier (Granulated)	17 "	14.75 "	2.6 "	26 "
Natrona	42.75 "	36.75 "	7.2 "	72 "

Dissolve the caustic soda in water. Dissolve the copper sulphate also in water in another vessel and dilute each to half the volume of the completed mixture, then mix the two solutions together.

If put together in the above proportions the mixture will be alkaline. If too little soda is used it will be acid, and it then liable to injure the leaves.

In order that the mixture may be more easily seen on the trees, and thus enable the operator to know when the tree has been completely sprayed, add a small quantity of lime, about one-half pound to every fifty gallons of mixture. This will be sufficient to make a visible deposit on the trunk and foliage of the tree, and enable one to distinguish easily the sprayed from the unsprayed portions.

The strength as given above is really the same as the 5-5-50 Bordeaux mixture. To make one equivalent to the 4-4-50, increase the amount of water by one-quarter.

AMMONIACAL SOLUTION OF COPPER CARBONATE.

This solution contains no sediment and on drying leaves no marks upon the fruit. It may therefore be used upon fruits in the latter stages of their ripening, when the spotting that the Bordeaux mixture causes precludes the use of that fungicide. The mixture consists of a solution made by dissolving copper carbonate in ammonia water in the following proportions:

Copper carbonate	6 ounces.
Ammonia, about	3 pints.
Water	50 gallons.

Weigh out the proper amount of copper carbonate, set a very small portion of this aside and dissolve the remainder of it in diluted ammonia, using only enough to dissolve it and then add the portion of copper carbonate which was reserved. This will insure that you use no more ammonia than is necessary. It is better to have a little too much of the copper carbonate in the solution than to have too much ammonia. A strong solution made in this way can be diluted with the proper amount of water. The copper carbonate may be purchased at any drug store.

BURGUNDY MIXTURE.

Copper sulphate	1 pound.
Sodium carbonate (sal soda)	1 1-2 pounds.
Water	50 gallons.

Each chemical should be dissolved separately in one-half the full amount of water and the two solutions then mixed as in making the Bordeaux mixture.

This non-spotting mixture may be used as a substitute for ammoniacal copper carbonate. It is cheaper and is said to be about equally effective.

Insect poisons should not be added to this mixture.

COPPER SULPHATE SOLUTION.

A solution consisting merely of copper sulphate and water may be used before the leaves appear to kill the spores on the trunks and branches of the trees. It is made as follows:

Copper sulphate	1 pound.
Water	17 gallons.

Dissolve the copper sulphate as you do in preparing the Bordeaux mixture, dilute it to the required strength and spray upon the trees. The addition of a little lime, half a pound to fifty gallons of mixture, enables the operator to see exactly what proportions of the tree have been sprayed.

This mixture must not be used after the leaves appear.

COPPER SULPHATE 1-7.

This is made as above, by using 7 instead of 17 gallons of water to one pound of copper sulphate.

POTASSIUM SULPHIDE SOLUTION.

Potassium sulphide (or liver of sulphur)	1 ounce.

This solution should be freshly prepared. It is used as a substitute for the Bordeaux mixture in the same way as Burgundy mixture, the ammoniacal solution of copper carbonate is used when the fruit has become so large that the Bordeaux mixture must be discontinued to avoid spotting. Potassium sulphide is especially efficient in protection against the powdery mildews.

LIME SULPHUR MIXTURES.

These insecticides (page 61) are also of fungicidal value and when used for insects the Bordeaux mixture of the same date may be omitted.

INDEX.

- Ammoniacal copper carbonate 122
- Anthracnose 113
- Apple, principal insects affecting—
  - caterpillars affecting foliage 67-73
  - green leaf aphis 65-67
  - round-headed and flat-headed borers 52-55
  - scale insects 58-64
  - shot-hole borer or fruit tree bark beetle 55-57
  - woolly aphis 45-51
  - worms occurring in fruit 73-82
- Apple curculio 82
- Apple diseases—
  - bitter rot 98
  - black rot 102
  - blight 89
  - blotch 100
  - brown rot 104
  - canker 101
  - fly speck 110
  - fruit rot 107
  - hypochnose 90
  - leaf spots 94
  - powdery mildew 103
  - ripe rot 98
  - rust 95
  - scab 87
  - scurf 103
  - soft rot 103
  - volutella rot 104
- Apple leaf aphis, green 65
- Apple tree tent caterpillar (*illustrated*) 67
- Apple twig borer 57
- Apple woolly aphis (*illustrated*) 45
- Apple worm (see codling moth) 73
- Bitter rot of apples 98
- Black rot of apples 102
- Blight, apple 89
- Blight, pear (*illustrated*) 111
- Blister mite, of pear leaves 85
- Blotch of apples (*illustrated*) 100
- Bordeaux mixture, preparation of 119
- Borers, in trunk and limbs—
  - round-headed apple tree 52
  - flat-headed apple tree 54
  - shot-hole 55
  - apple twig 57
  - Prionus spp. 83

Brown rot 104
Bud moth, eye-spotted 72
Burgundy mixture 122
Canker of apples 101
Canker of pear (*illustrated*) 115
Canker worms 71
Cedar apple rust (*illustrated*) 95
Codling moth (*illustrated*) 73
Copper sulphate solutions 123
Curculio, the plum 80
Curculio, the apple 82
Fall web-worm (*illustrated*) 69
Fire blight—
  of apples 89
  of pears 111
Flat-headed apple tree borer (*illustrated*) 54
Fly speck (*illustrated*) 110
Fruit rot (*illustrated*) 107
Fruit-tree bark beetle 55
Fungicides 119-123
Green apple leaf aphis 65
Hypochnose, of apples (*illustrated*) 90
  of pear 118
Kerosene emulsion, preparation of 50
Leaf spots, of apples (*illustrated*) 94
Leaf spots, of pears (*illustrated*) 116
Leaf blight, of apple and pear 116
Lime sulphur washes 61
Oyster shell scale (*illustrated*) 62
  remedial measures 63
Pear, insects affecting 83-85
  borers 83
  caterpillars on foliage 84
  pear-leaf blister mites 85
  scale insects 84
  worms in fruit 85
Pear diseases—
  anthracnose 113
  blight 111
  canker 115
  hypochnose 118
  leaf blight 116
  leaf spot 116
  rust 114
Plum curculio (*illustrated*) 80
Potassium sulphide solution 123
Powdery mildew 103
Prionus borers 83
Ripe rot of apples (*illustrated*) 98
Round-headed apple tree borer (*illustrated*) 52

Rust of apples 95
Rust of pear 114
San Jose scale (*illustrated*) 58
Scab disease of apples 87
Scurf of apples 103
Scurfy scale 64
Shot-hole borer 55
Soda Bordeaux 121
Soft rot of apples 103
Spraying recommendations, general 86
Tent caterpillar 67
Tobacco decoction 49
Twig borer, of apple 57
Volutella rot (*illustrated*) 104
Web-worm, the fall (*illustrated*) 69
Woolly aphis, of apples 45

BULLETIN 207 APRIL, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

HOG RAISING IN NORTH CAROLINA

Edwards & Broughton Printing Co.
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	LOCKE CRAIG	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

SUMMARY.

1. Swine raising should be made one of the leading live stock industries in North Carolina.

2. The climatic conditions are ideal for the production of swine because of the mild winters and the long growing periods, making it possible to produce grazing crops of many varieties.

3. The State of North Carolina has wonderful possibilities in the dairy industry. Swine production should be made a leading adjunct to this industry, making use of the valuable by-products from the dairy.

4. The long growing seasons and mild winters make it possible to rear two litters of pigs each year with very satisfactory results.

5. The State of North Carolina has an average of 24.9 hogs to the square mile, while Iowa, a State where conditions are not nearly so favorable for hog raising, the winters being long and cold, and the growing seasons short, has 175.3 hogs, or about seven times as many per square mile.

6. The swine industry in the State is held in check, very largely for three reasons: (1) Because of the use of a low grade of stock in breeding, which results in offspring of reduced size and inferior conformation. (2) Because a large majority of the growing, breeding and feeding hogs are kept in small, filthy, unsanitary pens, where range, pure water and sunshine are absolutely unknown, things which a hog must have to attain perfect health, symmetry, beauty and maximum weight. (3) Because fully three-fourths of the farmers raising swine in North Carolina have yet to learn that a hog is naturally a grazing animal and will derive fully one-half of his nourishment from grazing crops when allowed to do so.

7. Before the swine raising industry of the State is placed on a permanent basis, pure bred males must be used at the head of the herds. Grade or scrub sires are of no value whatever in making improvement. A strong boned, well framed, vigorous prepotent pure bred male will pay for himself in one year where as many as five sows are kept, and at the same time make permanent improvement in the herd.

8. Better use must be made of the numerous grazing crops which can be grown in abundance by Southern farmers. There is a tendency to use entirely too much high-priced corn for young growing animals. This practice not only leads to small gains, but brings on an unthrifty condition of the animals. Larger quantities of protein feeds, such as cowpeas, soy beans, wheat middlings and skim milk should be used, and these feeds should be supplemented with leguminous pastures especially during the growing period of the animal. Given plenty of exercise and freedom, pure water and sunshine, the gains will be larger on less feed and the health of the animals at the same time will be better maintained.

9. Hog cholera and swine plague are the two diseases most to be avoided, and every precaution should be taken to prevent outbreaks. All dead carcasses should be buried or burned, and disinfectants should be used freely on the hogs, lots, pens and houses. Filth that will attract buzzards and other scavengers should not be allowed to accumulate.

10. A large number of the hogs in this State are constantly harassed by lice and intestinal worms. The food under such circumstances to a considerable extent merely nourishes these parasites, the hogs generally remaining in an unthrifty condition. The farm can be cleared of these pests by keeping the premises clean and by using proper disinfectants and remedies, either home-made or proprietary.

11. As a general thing, the feeding and management of the farmer's herd could be improved. Extra care in management will doubly repay him in more and better hogs at marketing time.

HOG RAISING IN NORTH CAROLINA.

BY R. S. CURTIS, ANIMAL HUSBANDMAN.

The natural inducements for the production of high-class swine in North Carolina have appealed especially to the writer after visiting various sections of the State and fully acquainting himself with the natural advantages afforded. The chief reason, however, for writing this bulletin came about through the numerous inquiries which come to the Station regarding the possibilities for raising swine in the State and the best methods to use and crops to grow. These inquiries have not been confined to farmers of the State alone, but have come also from Northern farmers, and capitalists who have quite recently learned the peculiar natural advantages existing in the South. With this fact in view, it was thought likely some material aid might be rendered on the general subject of swine production by a publication of this nature.

Every farmer who raises hogs should have a fundamental knowledge regarding the prevention of the more common diseases and how to treat the animals, should the herd become affected.

In this bulletin the feeding, care, and management of swine will be dwelt upon chiefly. Only the most common ailments will be discussed, and these from the standpoint of prevention rather than cure. With a hog, especially, disease is likely to prove fatal in many instances where other animals might survive. They do not respond well to treatment, consequently, great care should be taken to prevent contraction of disease.

ADAPTABILITY OF STATE FOR SWINE GROWING.

The question, concerning the adaptability of the State for swine growing, is asked almost invariably by men who anticipate taking up this line of work. In answer to the question it may be stated emphatically that the conditions are not far from ideal. While the State varies greatly in soil and climatic conditions, which makes a wide variation in the crops produced, yet no section is without its peculiar advantages of soil, climate and crops.

The mountains have their natural pasture lands, corn and other cereals, including the mast of the forest which Nature originally provided for the undomesticated hog. The Piedmont and Coastal sections each have their corn, cowpeas, soja beans and other grazing crops, such as rape, Canada field peas, oats, rye and clover. These with the many other important grain and grass crops which can be grown throughout the State make the conditions quite favorable. Heavy feeding throughout the winter is not necessary, as the climatic conditions are such that the hog does not require large amounts in excess of that provided during the summer season. The mountainous section will furnish the one exception, but even here, the rigidity of the climate is more than offset by other natural advantages.

Concerning the market conditions, the South will undoubtedly furnish a market for all of the pork produced, as large quantities are imported each year from the North and West to make up for the deficiency. The central markets, such as Richmond and Baltimore, besides the many local markets throughout the State, will furnish an outlet for many more hogs than are now annually produced.

CONDITION OF SWINE INDUSTRY.

The swine industry of North Carolina is in a very unsatisfactory condition; first, because of the small number of hogs actually raised, and the large amount of pork annually imported from the North and West; and second, because of the inferior grade of stock which is used for breeding and fattening purposes largely by the smaller farmers. In many instances farmers keep well-bred stock confined in small, filthy, unsanitary pens and lots, and wonder why their profits are not larger. This condition has arisen from the fact that some men have the idea that well-bred stock is capable of making its own livelihood. This is a common conclusion, yet a very erroneous one. It is much better to retain the inferior stock if proper care and attention are not given. The pure bred stock will soon deteriorate under improper management while the scrub will more nearly hold his own under unfavorable conditions. It has taken years to breed the pure bred hog to his present standard, but he will revert rapidly unless proper care and attention are given. This statement does not imply that pure bred animals must be pampered to make swine growing successful, but it does imply that plenty of exercise, pasture, sunshine, pure water and an abundance of nutritious feed must be given. Any one who is making an attempt to breed swine will find it to his advantage to keep only well bred hogs, as those of inferior breeding will be more expensive to grow than the former, and they are otherwise generally unsatisfactory for breeding purposes. In fact, many of the inferior specimens found on North Carolina farms cost the owners far more for their keep than it would for an equal number of well bred hogs. Scrub hogs generally make small and unprofitable gains, and meat so produced is never of the best quality.

The number of hogs produced in the State annually is totally inadequate for its supply. There is imported annually thousands of pounds of pork from States far less favorably located and adapted for the production of swine than North Carolina. Iowa has almost eight and one-half million more hogs than North Carolina with but 3,000 square miles greater area. In that climate grazing crops can not be produced ten months in the year as in North Carolina, and furthermore during the season when hogs in this State are grazing on a variety of pasture crops, the Iowa farmer is feeding on costly harvested feeds such as corn, barley, rye and the by-products from the wheat grain. Fifty to seventy-five per cent of this feed is used for heat and energy during the long cold winters, while under Southern conditions, heavy feeding is necessary only for a comparatively short period during the winter months.

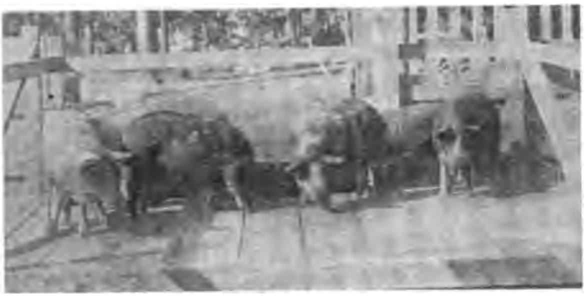


Fig. 1.—Inferior Feeding Hogs.

In the face of these facts, however, North Carolina has only one hog for every twenty-six acres where Iowa has seven. There is simply no way to account for this condition other than the fact that we have not set ourselves to the task of growing more and better hogs. Our conditions are more favorable from any standpoint. Instead of relying on the Northern and Western States for pork supplies there seems to be no good reason why North Carolina should not become one of the largest pork-producing States if diligent and intelligent effort is given to this industry.

NATURAL INSTINCTS OF THE HOG.

In the care of domestic animals, the nearer we can imitate nature in providing food and environment the greater the chances for success.

The care and management of swine furnishes no exception to the rule, as the hog is peculiarly adapted to that environment which surrounded him in his natural haunts. This fact, a great many have lost sight of, at least apparently so, considering the conditions in which many of these animals are maintained.

As an example of the peculiar nature of the hog, if he is confined closely he will resort to rooting, a natural trait of his ancestors developed necessarily while searching for food in the forest. This trait has been transmitted to a certain extent to animals under domestication. The best results can not be obtained, however, under close confinement, for no animal thrives well under restraint.

In his natural haunts, the hog was accustomed to abundant exercises, sunshine, pure air, fresh water, roots, herbs, acorns, worms, and natural grasses. These are a delight to him and to attain the greatest success in swine raising, a variety of rations which will furnish these necessities in their various forms, should be provided. It is not absolutely necessary, nor at all times profitable to imitate nature in every detail, yet it should be done as far as practical. Fresh air, sunshine, pure water, and lots for exercise can usually be provided without great cost or much effort. Sweet potatoes, artichokes, peanuts, mangels, turnips, cowpeas, soja beans and many other field crops, suitable for grazing purposes will grow in most sections of the State, and at least three or four of them will be found to do well in any section. If these pasture and root crops are properly supplemented with concentrated feeds, any intelligent farmer should be able to make a success growing hogs provided proper care and judgment are used in managing the herd.

SELECTING THE BREED.

What breed to choose is a question often raised, and in many instances the mistake is made of placing too much stress upon the breed and not enough on the individual animal of that breed. We have a number of recognized breeds to choose from, yet each of them has its inferior specimens, unsuitable for breeding or feeding purposes. This is a point of special importance, yet many times it is given insufficient consideration by the prospective purchaser. The breed may be excellent, while the individual may be a scrub.

The Berkshire is the predominant breed in the South, and generally speaking they are giving quite satisfactory results as breeders and feeders, yet there are other breeds that will give equally satisfactory results with the same care and management. Strictly speaking, that breed should be selected by the individual farmer which fits into his conditions and serves his purposes best. For example, the man who is making a business of growing breeding stock, should first consider the demand for the particular breed which he anticipates growing. He should also study the peculiar conditions which would tend to make one breed more successful than another, also his own particular likes and dislikes. No stockman can be entirely successful who does not take special pride in the breed which he champions.

On the other hand, if the production of market hogs is the sole purpose, the outlet for breeding stock need not receive special consideration, as individuals of most of the breeds can be put in a very satisfactory condition for the market. It is true that some breeds will mature earlier and require less feed to produce a pound of gain. The consumer is not particular, however, concerning the breed or the origin of the pork placed on his table, providing the quality is right. Individuals and not breeds are the deciding factors at the stock yards, the packing houses and the retail market.

A full list of recognized breeds is given on page 183 of this Bulletin. These breeds all have their strong points, and will return very satisfactory profits in the South, if properly managed. In selecting the breed, utility and service should receive special consideration. As the individual is of greater importance than the breed, the judgment of the breeder will be tested by individual selections made for the perpetuation of ideal types.

SELECTION OF THE BOAR.

In selecting a boar to head the herd, there are certain fundamental points which should be given serious consideration. The boar should first of all be a healthy, vigorous individual and a representative type of the breed, as a pure bred scrub is costly at any price. The value of the boar is determined by a few striking characteristics known to the practical breeder as masculinity, prepotency, size, constitution, form and quality. If the boar is rigidly selected, paying particular attention to these points, he is likely to prove satisfactory.

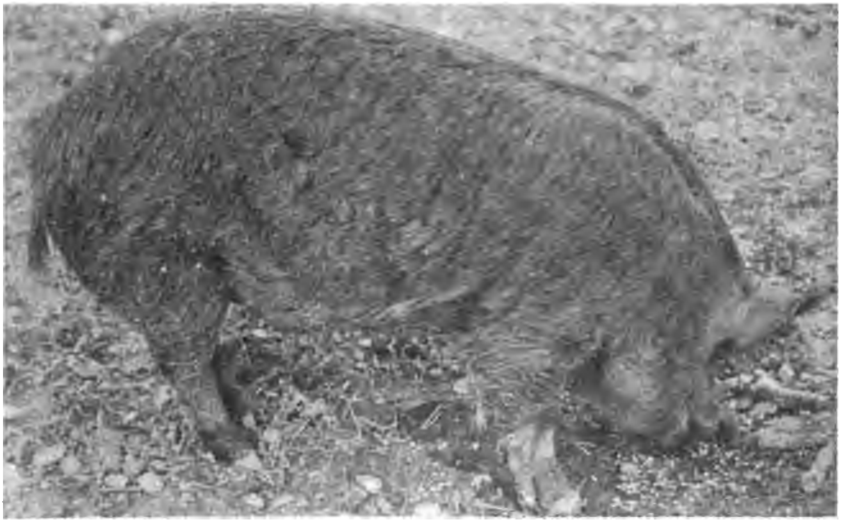


FIG. 2.—A Prepotent Berkshire Boar.

As to the masculinity of the animal, select one which has that bold fearless appearance necessary to make him physically strong and prepotent. The head should be short, broad and full; the eyes large and bright; the neck, shoulders and body, broad and deep, which is naturally expected to be found in a healthy, vigorous animal. See that the nostrils are well developed and the chest broad and deep. These points indicate constitution and vitality. Do not select an animal which has a long, narrow head, small eyes, thinly set shoulders and lacks in width and depth of body throughout.

A boar possessing the least degree of femininity should not be used. Such an animal is generally weak and impotent, begetting small, unthrifty pigs. Select always the healthy, robust, energetic animal with plenty of quality and substance.

The prepotency of an animal can not be determined definitely by the ordinary physical examination, as it is impossible to say with absolute surety that this or that animal will be a satisfactory breeder without making an actual breeding test. We have fortunately, however, things observable in the animal which indicate this character. After this we can study only the ancestors of the animal. It is important to select according to the strength of the characters as indicated in the individual. If we couple the essential characteristics of the strong, vigorous individual with a line of prepotent ancestors for four or five generations back, the chances for making a successful selection are greatly increased. Select the boar from ancestors which have shown prepotency on the male side and prolificacy on the female side. This is important, and yet it is a point which is too often not given proper consideration.

The boar should possess great size. He will get pigs which attain a given weight at a younger age than a boar which does not possess this quality. Lack of proper judgment in selecting breeding animals, possessing sufficient size, is responsible to a large extent for the small type of hogs grown so commonly.

The constitution of the animal is indicated in a general way by the size and vigor. Additional indications of constitution are shown by large, open nostrils; short and broad head, large, clear, bright eyes; full and firm jowl, and a broad, deep chest.

Select breeding animals with a large, clean, dense bone, fine silky hair and clear-cut features about the head and neck. The shoulders should be broad, deep and smoothly formed, yet free from that coarseness which characterizes the animal of inferior quality. Discrimination should be made against swirls, which most commonly appear along the back. Large, coarse, upstanding bristles are to be avoided, as they indicate coarseness.

The form of the animal should be broad, deep and long, with short straight legs, standing squarely on the pasterns. The animal should have a broad back, long, deep sides and a clear-cut outline. The neck should be short, blending evenly into the body with a full shoulder vein. The shoulders should be broad, deep, well filled and evenly covered over the top, as an open shoulder indicates inferior quality.

The back should be slightly arched, the sides uniform, and carried well down toward the underline, thus giving depth and capacity. Depressions back of the shoulders and in front of the rear quarters are bad. In fact, any roughness which detracts from the beauty or usefulness of the animal should be avoided. The flanks should be full, and the width of the animal at the shoulders should be carried to the rear quarters uniformly. The sides should be even and free from lumps or wrinkles.

The rear quarters should possess length, depth, width and be well filled both outside and in the quarters. The smooth, well-rounded rump and thighs are very much sought after. Avoid a drooping rump, as it is unsightly and detracts from the actual value of the animal. The tail should be set high and the rear quarters, as a whole, conform to the other parts of the body.

In summing up, select for health, masculinity, propotency, size, constitution, form and quality, which will insure almost invariably a rugged, active, vigorous animal.

SELECTION OF THE SOW.

In selecting a sow, a great many of the same general principles hold as for the boar. The sow should have all the characteristics of femininity, which are indicated by the clear-cut features about the head, neck, shoulders and body. The head should be short and broad without undue coarseness, having that mild expression or character which is possessed by the good mother. The eyes should be mild, large, clear and bright; and the ears of medium size and fine in quality. The jowl, as in the boar, should be full and firm, yet not large or coarse. The hair should be fine and silky, without any evidence of bristles in the coat. While the term feminity is rather difficult to define, it is in many respects the exact opposite of masculinity. The other points of primary importance are prolificacy, constitution, form, quality and breeding capacity.

Prolificacy signifies the power to bring forth young in uniformly large numbers. This is a characteristic which can not be determned by making a simple examination of the animal. The ancestors of the animal in question must be studied in determining the degree of prolificacy of a sow. It is not always possible to make an accurate study of this point, however, since only pure bred animals are recorded, and comparatively few men keep permanent breeding records. In selecting either boars or sows, it is important that a tentative selection be made while they are still suckling the mother. In this way, the size of the litter and the uniformity of same may be determined.

The mother should be an animal of strength and vigor, as it is necessary for the feed which she eats not only to maintain her own body, but at the same time nourish a litter of pigs. A really useful sow should be capable of doing this work for a period of five or six years or even longer. This requires a strong constitution, which is indicated by a broad, deep chest, large snout and nostrils, large, clear bright eyes, a broad and deep chest and plenty of capacity for digesting large quantities of food.

The form of the brood sow should be that of a parallelogram with a long, deep and broad body, standing on short, straight, strong legs, and feet with pasterns erect. The body should be compact, as this typifies a good feeding animal. The head should be short, broad and deep; neck short; jowl full and firm; shoulders broad, smooth and deep; back slightly arched; sides even, and the width of the body at the shoulder carried out to the buttock. This is a point where a great many animals are weak, the body as a whole growing narrow toward the rear quarters. The sow with deep sides and a long underline, has generally great capacity, as the teats are more likely to be large, numerous and well placed. At least twelve well-formed teats should be in evidence.

The quality of the sow is indicated exactly in the same manner as in the boar. The features should be clear-cut, shoulders compact, body smooth and uniform throughout, covered with a fine, silky, glossy coat of straight hair. The bone should be clean, firm and dense, with just enough size to carry the weight which the animal will be subjected to. It is better to select an animal with a bone somewhat coarse than one that has insufficient bone to carry the weight.

Without the proper symmetry and development, of these characteristics, the value of the animal is largely destroyed. Select the brood sow which has first of all health, femininity, a long, broad and deep body with large capacity, and a record showing prolific ancestors.

THE WHITE HOG.

The white hog is not commonly bred in the South, although the prejudice which exists is of an exaggerated form, especially in the mountain regions. These hogs are bred successfully in some portions of the State, and they will probably be bred to a greater extent in the future. The western, or mountainous portion of the State, is as well adapted for growing the white hog, as the country claiming his natural habitat. The writer has seen most excellent specimens of these hogs grown in the mountains, and inquiry revealed none of the troubles from skin irritation to which they are said to be subject. Even in the central section of the State, the several breeders of the white hog have found them to give satisfaction.

North Carolina will eventually become a great swine growing State, as no country so naturally adapted to this industry can remain undeveloped. Breeders of other sections of the country are already beginning to investigate the possibilities of breeding swine in this State, and with their improved methods of management, there is bound to follow a greater differentiation regarding the selection of breeds. Certainly, the white hog deserves a fair trial, and those breeds purporting to have inherent bacon characteristics should have due consideration. It is not the intention to advocate white hogs or any other breed of swine, but rather to emphasize the importance of selecting animals which serve the purposes best for which they are grown. In many cases in the South where swine breeding has not proved successful, it has resulted from lack of proper management, rather than from ascribed faults and deficiences in the breeds tried.

REGISTRATION.

There is a general misapprehension regarding the methods and requirements necessary for the proper registration of pure bred swine. This is of special importance, as it is evident that many stock growers have been misled by having worthless pedigrees furnished them. When purchasing animals, the pedigree furnished should be on the prescribed form invariably used by the breed association in question, and the validity of the record indicated by the signature of the secretary of the association.

Eligibility to registration is not sufficient, yet this opinion is prevalent. An animal which has special merit deserves to be recorded in the herd book maintained for that purpose. This distinction is due every animal which is capable of improving our live stock, as such animals are comparatively rare. Reliance on slip-shod methods of keeping records should be discouraged. The herd books for the respective breeds of live stock were established for this particular purpose. They have brought order out of chaos, by organizing in case of most breeds, one common registry association. The small fee charged for recording animals of special merit will bring financial returns quite sufficient to pay the original outlay, and in most cases profitable returns for the extra work involved.

In buying pure bred animals purchase only from men who are thoroughly reliable. This is important for the breeding of the animal purchased, and the value of the pedigree depends to a large extent on the reliability of the breeder. The writer does not wish to convey the impression that pedigree is the only necessary point to emphasize. Get individuality in the animal also. Do not pay for a long pedigree unless the animal conforms to proper type in every detail, and its ancestors have shown themselves to be individuals of special merit. The purchaser of pure bred animals should not be satisfied until he has pedigree and individuality combined.

FEEDING AND MANAGEMENT.

The feeding and management of breeding hogs calls for special attention and in many instances it is found that the care given is entirely inadequate to insure success. This is especially true with the small farmer who does not make a specialty of the swine business. In a great many cases the breeding animals get exactly the same care and feed as the fattening hogs. This is a grave mistake, and if the troubles which often come at farrowing time were traced, it would be found in many instances that they originated in the fattening pen. A difference must be made between the feeding and managment of the market hog and the breeding hog, if success is to be achieved.

The animal which is intended for breeding purposes, whether male or female, should first of all get plenty of exercise and nutritious feed. These are necessary if a strong, thrifty hog, with plenty of bone and muscle is to be grown. As a long period of usefulness in the breeding animal is looked for, they should always be started in life properly and kept growing. With the fattening hog, the case is somewhat different, as the desire is to get him on the market at an early age, and with as much weight as possible. The period of usefulness here is comparatively short as the final product goes to the butcher's block. The aim should be to separate the fattening and breeding hogs rather early in life. This should not be done, however, before the breeding animals have developed sufficiently to indicate what they will be at maturity. An animal while young may be promising, yet a disappointment when grown. The breeding and fattening hogs should be divided by the time they are three and one-half to four months old. From this time on keep them in separate lots and pastures. The market hogs can then be pushed along as fast as practical, while the breeding animals should be allowed the run of a pasture where green feed and pure water are available, and exercise may be taken freely.

Keep the breeding animals growing as long as possible, and do not at any time allow excessive fat to accumulate. This is a detriment to any animal intended primarily for breeding purposes. Keep the boar and sow in a medium fleshy condition. This can be done by allowing plenty of range, and withholding fattening feeds such as corn and peanuts. Give plenty of feeds rich in protein such as clover, alfalfa, peas, beans, bran or middlings, and when possible make the hogs glean part of their livelihood by harvesting the feeds which have been planted especially for them. By so doing the boar will be more active and prepotent, getting larger and stronger pigs; while the sow will be less likely to have trouble at farrowing time, and will not so readily eat or overlay her young.

The breeding animals should be fed well at all times, but under no circumstances should they be crowded. The boar should have a heavier ration during the breeding season than otherwise as the work which is being done requires energy, while the sow should be especially well fed and cared for during the time she is suckling her pigs. It is not so likely that the feeding will be overdone at this time as the pigs are a heavy draw on the mother. Feed with judgment, taking into consideration the work which the animal is doing. Do not under any circumstances keep breeding animals confined in small unsanitary lots or buildings. Give them exercise, sunshine, and pure water, even if it is necessary to do so in a large dry lot. Do not confine them simply because pasture is not available. The other important necessities, sunshine, fresh air, pure water and exercise can be furnished in a dry lot as well as in a pasture, although pasture should be furnished when possible, especially for the beneficial effect the green material will have on the digestive system and consequently on the general health and vigor of the animals.

AGE TO BREED YOUNG ANIMALS.

It is not a wise practice to breed young sows before they are eight months old, and better still if they are allowed to go until they are ten months or even a year old. It is especially advisable to keep the less vigorous females from the boar until they are one year old as the extra work of nourishing a litter of pigs will greatly sap their vitality. A sow which is bred too young never develops into the strong, robust, healthy animal necessary to do long, useful service

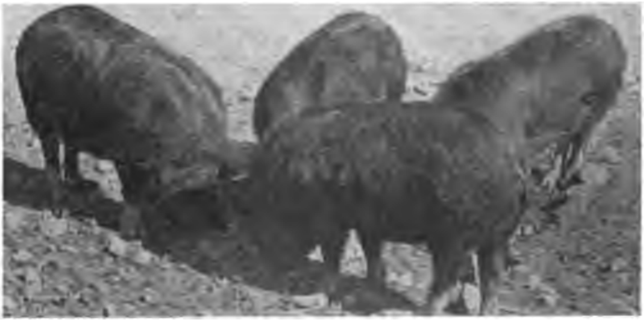


FIG. 3.—Berkshire Gilts Showing Proper Type.

in the herd. Where two litters of pigs are raised each year, the wisdom of allowing the young sows to go well along toward maturity before breeding is evident. If the young females are robust and vigorous, they may be bred at eight months, and the results will be quite satisfactory. The tendency, however, with many breeders is to put the females to work entirely too early in life. The result is that they not only fail to mature properly, but their offspring generally makes a slow, unsatisfactory growth, and consequently the succeeding generations are likely to be inferior breeders also. If a young sow is bred for spring farrow, she should really go over until the following spring before farrowing the second time, and after that be bred twice per year. This may seem to some like a waste of time, but the extra strong pigs reared during the life of females managed in this way will easily make up for the loss of time in starting.

The young boar, like the young sow, should not be used too often and not too early in life. If he is allowed to serve sows when he is much less than eight months old, it is likely to injure him. With the boar, however, it is somewhat different than with the sow as he can be served a few times, and gradually brought into regular service without placing the entire strain upon him at once.

CONDITION OF SOWS FOR BREEDING.

Females intended for breeding purposes should be in medium condition at time of service. This condition should be maintained quite uniformly until farrowing time as sows in high condition at this period are often feverish and experience considerable trouble giving birth to their young. A half starved condition during the period of gestation is very harmful, as the litter can not be nourished properly in utero, and after the pigs begin to suckle heavily it is impossible to get the mother back to her normal strength. If the sow is fed on cooling feeds during the period of gestation, she will be much better prepared to meet the demands of motherhood. Not until the pigs are three or four weeks old, should she be placed on a heavy ration. After this time, liberal feeding may be resorted to without harm to the mother or litter. During the gestation period the sow should have an abundance of exercise and succulent feed, as nothing will be of greater benefit in preparing her to farrow a strong, healthy litter of pigs. This will also have a tendency to correct the evils resulting from an ill-balanced ration should, for any reason, a ration of this character be fed. In fact, exercise is one of the best correctives for an animal which is being fed a heavy fattening ration. With experienced breeders, over-feeding of this sort rarely if ever occurs, but with the beginner, sometimes the outcome can not be regulated satisfactorily. If at any time brood sows have a tendency to become too fat near farrowing time, the feed should be decreased and the amount of exercise increased, but the change should be made gradually or serious trouble may arise.

Linseed meal is an excellent feed for the brood sow owing to the cooling effect of a ration containing this material. The percentage of protein in linseed meal is high, consequently there is no tendency to lay on fat in excess of the needs of the animal body, and the laxative effect of this feed keeps the digestive system in proper condition for farrowing. If linseed meal is not fed regularly, it is a good plan to provide for a small amount of it or a similar material in the ration about three or four weeks before the sow farrows. A ration composed largely of corn, fed at this time, is exceedingly bad as it keeps the system heated and feverish and results in much trouble at farrowing time. If a half-pound of linseed meal is fed to each sow three weeks prior to farrowing, the results will generally be quite satisfactory. Farrowing time is a critical stage in swine management, and additional feed of the proper composition, and extra care, will prove highly remunerative to the swine farmer.

CARE OF SOW AND PIGS AT FARROWING TIME.

About two weeks before the sow is ready to farrow, she should be taken from the others in the herd and placed in a small lot or pasture by herself. This will give her time to become accustomed to the new surroundings before farrowing. If she is molested by other animals, it may cause much trouble and loss. Leave the sow to herself as much as possible, unless it is with the regular feeder who should understand thoroughly how to handle each individual animal in the herd. Much of the success in swine raising is due to having the proper attendant who is always on hand at farrowing time.

See that proper shelter, bedding, feed and water are provided regularly and in sufficient quantities. A few days before the sow farrows, she will show signs of uneasiness and probably arrange her bed. Cater to her wants and she will generally bring a large, strong litter of pigs in return for the trouble. The attendant should watch the sow carefully at the time the pigs are expected to come, and render any help that is needed. Do not trouble her, however, unless necessary. If the sow has been fed properly and allowed plenty of exercise during the gestation period, few times, if ever, will help be needed.

Some breeders follow the practice of removing the pigs from the sow as soon as they have been delivered, and in many cases, it is advisable especially if the weather is cold, and the pigs are likely to be chilled before the mother can care for them. Then, too, some of the pigs may be overlaid by the sow during the time she is farrowing. A large, clumsy sow, or one which is in a fattened, feverish condition is most likely to do this. With the average farmer it is not likely that he will follow the practice of removing the pigs, yet if there is any danger of losing them from cold, or accident, they should be taken from the mother and placed in a basket filled with straw, grass or bran. If the cold is more than ordinary, the pigs may be taken to the fire until they are thoroughly dried, and returned to the mother every hour or two for nourishment until it is safe to leave them with her.

It is a practice commonly followed by breeders to pinch off the black teeth, as it often saves much trouble and annoyance to the young pigs when they become old enough to fight rather vigorously. These teeth are snipped off when the pigs are quite young, often just after birth. If the pigs are taken from the mother as recommended in some cases, the operation can be performed without inconveniencing them in the least.

If good judgment is used in feeding the sow during the gestation period, and plenty of water, exercise and sunshine are provided, success will generally be insured at farrowing time. After farrowing, the sow will be in a feverish condition, and the ration should be light and especially palatable for a few days. She will not eat much at first, but gradually the desire for her regular feed will return. If in the winter time, heat the drinking water to remove the chill. See that she is properly bedded at all times with short fine straw, and warm shelter is provided. Warm skim-milk, wheat middlings, ground corn and sifted oats make a good slop for the sow and her pigs during the suckling period. If skim-milk is not available, a small amount of tankage may be used. Keep the sow and litter in the lot for two or three weeks prior to being placed on pasture. If possible provide a separate pasture for each sow until the pigs are weaned. After this they may be cared for as the owner sees fit. Pigs intended for breeding may then be placed in one pasture, and those for fattening purposes in another, where special care can be given each lot of pigs as necessity requires.

MILKING CAPACITY OF BROOD SOWS.

The milking capacity of brood sows varies greatly, both from hereditary qualities and the character of the feed furnished. Their capacity in this respect varies the same as with dairy cattle. Brood sows which are not capable of furnishing sufficient milk to nourish a litter of strong, thrifty pigs should be discarded. Failure to get the proper growth and size on suckling pigs is often due to an inadequate milk supply. It may be due, however, to the milk lacking in nourishment or directly to an improper feed supply for the mother. The first fault, however, the natural deficiency in milk production, is the one to receive primary consideration. For the foundation herd only females should be selected which are naturally heavy milkers, and when they are discarded their place should be filled with animals descended from females having the same characteristics. Other desirable qualities should not be ignored, however, in selecting females for large milking capacity. Size, stamina, constitution, form and quality should be duly considered in selecting an animal for breeding purposes.

PERIOD OF USEFULNESS.

The length of time that the male and female do service in the herd should be limited only by natural causes. This implies, of necessity, that the original breeding stock was of the proper type, since no animal can be eliminated from the herd too quickly if it has nothing to commend it as a breeder. Select the useful animals as indicated by size, quality, form and breeding capacity. Give them a fair trial and if they prove to be satisfactory breeders, retain them, if lacking in any way discard them. A tried and proved individual is worth a half dozen untried ones. Both male and female, if properly fed and cared for should be able to breed satisfactorily for five or six years. Masterpiece, one of the great Berkshire boars is breeding vigorously at eight years of age. After long service, however, the boar may become clumsy and unable to handle himself properly. He should be discarded, therefore, before his prepotency begins to weaken. The sow, too, in some cases becomes indifferent, large and clumsy, often overlaying her pigs. Such females should not be retained, as they will likely not breed satisfactorily again.

It is better to discard these animals and replace them with individuals selected from the younger stock in the herd. Generally speaking, when a breeding animal, male or female, becomes indifferent, and they lose their natural energy and vitality which every good breeder possesses, they should be replaced with new individuals.

Some men have the idea, however, that breeding animals have served their period of usefulness at the end of the second or third year. This is a grave mistake. No man can afford to sacrifice a good breeder under any circumstances, considering the matter from a practical standpoint. Do not keep animals, however, after their energy, vitality and breeding powers begin to weaken. This is just as grave a mistake as to sacrifice them because they are somewhat aged.

It is hardly probable that when a man starts in the swine raising business every female he selects will be a satisfactory breeder. These unsatisfactory individuals must be replaced by new and probably untried ones, if they are selected from the owner's herd, and this necessarily is the most practical method of improvement. Consequently every breeder should aim to reserve his choicest females to replenish the herd as the older animals are eliminated.

NUMBER OF LITTERS.

The number of litters to raise each year will depend altogether on the vitality of the females in the herd, as well as on the equipment, such as buildings and pens, for successfully housing young pigs during the winter months. Under southern conditions, two litters may be raised without incurring much additional expense for winter feeding if the herd is managed properly. However, immature females should be bred only once per year. If two litters are produced, unless the females are exceptionally strong individuals, the normal growth will very likely be materially checked. Only strong, vigorous, mature brood sows should be bred twice per year. In planning for two litters it is best to have the pigs come as early in the spring as is consistent with climatic conditions. By so doing, the pigs may be weaned by May first to fifteenth, and the sows bred again early in June. This will give the fall pigs an opportunity to make a good start in life before the colder weather comes on. This is an important matter, as young pigs once stunted by cold or improper feeding will never make up for the loss, at least not without considerable additional expense. If a man is so situated that he can care for very young pigs during the severest weather, it is not so important to have the pigs come early in the fall. For the smaller farmer, however, early fall pigs will make better headway, as they will attain sufficient size to withstand the colder days and nights later in the season.

It is very essential in rearing two litters per year to provide plenty of green feed, as the young pigs get their start from the milk of the mother, and unless feeds are supplied which stimulate milk production, a great loss will necessarily follow. It is comparatively easy under southern conditions to supply pasture at least ten months in the year, and thus give the pigs an opportunity to make their normal growth. This is an important phase of the swine business which is too often neglected, and one which must be remedied before the industry is placed on a creditable basis. Farm grown feeds should constitute a large part of the ration, as they will cheapen the cost of production greatly.

In growing two litters, provide plenty of shelter, breed only from fully matured stock, and supply rich green feeds in abundance the year around if possible. When these feeds are properly supplemented with concentrates such as corn and middlings, success is most likely to follow, provided the herd has otherwise been properly managed.

SIZE OF LITTERS.

The size of the litter will depend quite largely on the individuality and prolificacy of the sow and her general care and treatment. Age will influence prolificacy within certain limits. Young sows with their first farrow do not generally give birth to large litters, and this is quite well since if six or seven strong, healthy pigs are raised to maturity, the young sow has performed her part well. Older and larger sows will, as a general thing, bring larger litters, and raise them satisfactorily. There is a reason for this, however, and it should be carefully considered before a young sow is discarded because she brings small litters. The mature female, that is, one having her normal growth of bone and muscle, can spend all of her energy in nourishing her pigs with the exception of that portion used in maintaining her own body. Young sows on the other hand have a third mission to perform, and that is the nourishing of the growing tissues, bones and muscles. If additional effort must be made by the young sow to nourish a very large litter, this task must be performed at the expense of the normal growth of her own body. Give the young sow a fair trial. It is far better to raise six or seven strong, healthy pigs than to raise nine or ten weaklings. Take into consideration all the factors influencing size of litters. Even seven or eight strong boned, healthy, vigorous pigs is enough for the mature sow, and especially is this true, if she farrows twice each year. Give the females a fair trial, and if they do not come up to standard, after the second farrow, discard them. Do not expect a dozen or more pigs in each litter. If you have a female capable of doing this satisfactorily, retain her, but on the other hand do not expect every animal in the herd to equal this record. This is an exception, and ordinarily seven or eight pigs to the litter properly cared for will return a very satisfactory profit.

WEANING PIGS.

The weaning of a litter of pigs is not a difficult task if they have been fed correctly from the beginning. If feeds have been provided that can be eaten and digested readily by the small pigs, they can be removed from the mother after two months without any noticeable inconvenience. This is a critical time in the life of the pig, and an effort should be made to make the change of rations gradually. Any sudden departure from the normal ration will be noticed, especially by suckling pigs, and they will be stunted accordingly. Aim to keep them growing from birth until maturity without a break in their daily gains.

If warm skim-milk can be provided, the pigs will soon learn to go to the trough with the mother and drink with her. The skim-milk should be supplemented with wheat middlings, ground corn, oats, rye, or tankage. All of these feeds are good and local conditions will determine which should be used. Provide green pasture at all times for the brood sow. Coarse, bulky feeds should not be given to the sow and her litter at this stage. Most of the feed should be in a concentrated form and easily digestible.

In carrying out the feeding directions, a creep or separate enclosure should be provided for the pigs in one corner of the lot or pasture to which the sow can not have access. Leave a space below the bottom board through which the pigs may go and have an equal chance with each other. By providing this at the start, the pigs learn to eat early in life, and they may be weaned when eight weeks old, and the sow bred again for a second litter of pigs. If this method is used, the change of rations and separation from the mother will scarcely be noticed by the young pigs if they have been fed properly up to this time. Whatever the method of management make the change of rations gradually.

The pigs intended primarily for breeding purposes may be left with the mother for a longer time than stated above, provided they do not suckle too heavily and cause a great drain upon her. Some breeders do not wean the pigs until they are three or more months old. In the production of breeding animals, the aim should be to get plenty of bone and muscle, the mother's milk being especially conducive to rapid development of these parts.

VALUE OF SUNSHINE.

The value of sunshine for young pigs is of such great importance that special mention seems necessary. It is commonly accepted

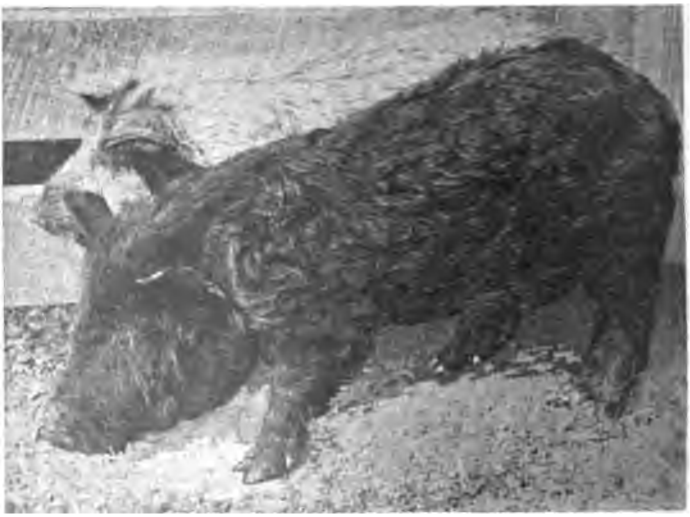


FIG. 4.—Unthrifty, Lousy Hogs.

among swine growers that pigs born during a continued period of wet, cloudy, weather will receive a serious setback which is seldom, if ever entirely, overcome, and in many cases death results, if the period of damp, cold weather is prolonged. The only preventative for this trouble is sunshine. When the weather permits, the pigs should be out in the sun as much as possible, for if it is withheld, trouble is sure to arise. Plenty of sunshine in the clear air is almost an absolute necessity during the first few weeks of the pig's life. Pigs confined in damp, ill ventilated quarters are sure to become unthrifty and may eventually die. There is no reason for close confinement, however, under southern conditions, as there is seldom a day in winter when small pigs can not have access to a sunny lot or pasture which will add greatly to their health and comfort.

GESTATION PERIOD AND TIME OF HEAT.

The normal period of gestation in the sow is about one hundred and twelve days or approximately four months. The extreme range is from one hundred and nine to one hundred and forty-three days. Gestation tables are very convenient as they are made in such a way that the date of farrowing can be determined readily, providing the date of service is known. It is important to keep a record of each sow, giving date last served, as by doing so they can be isolated ten days or two weeks before farrowing time, thus allowing them to grow accustomed to the new quarters, and prevent the destruction of their litters by other animals in the lot or pasture.

Normally, sows come in heat about every three weeks and remain so for three days or thereabouts, except during the period of gestation. The sow usually comes in heat about the third day after farrowing, but should not be bred at this time as the double task of nourishing pigs in utero and at the udder would soon sap the vitality of the most vigorous mother. The sow will not come in heat again, normally, until ten days or two weeks after the pigs are weaned. If it is expected to rear two litters per year, she should be bred at the first period of heat after the pigs are weaned.

Quite often breeders of pure bred stock wishing to develop the pigs exceptionally well do not wean them until after they are two and one-half or three months of age. They then allow the sows to recover fully, which practice will admit of growing three strong litters every two years if it is desired to do so.

TYPE OF HOUSE.

Expensive shelter for the southern climate is not necessary. In fact, excepting for a few months during the winter, the shelter may be very simple in most cases. If two litters are raised annually, it will be necessary to have warm farrowing pens, or otherwise considerable loss may occur during the winter from sows farrowing at this time. For most cases, however, the A-shaped house, large enough for one sow and her litter, or the common shed-roof house open to the south will suffice. These will allow the sunshine to thoroughly warm the quarters during the day and still be comfortable at night, even during stormy weather, if sufficient bedding is provided. If a sash of glass is used, these open houses may be closed, with the exception of a small opening to allow the sow and her litter access to the buildings. Fig. 5 shows a shed-roof house which has been used satisfactorily during the past two winters on the Station farm. The double farrowing pens open to the south have also been used successfully in rearing sixty spring pigs. At no time did occasion demand larger or more expensive shelter. It is possible that for exceptionally early spring pigs, a building entirely closed could be used to advantage. If such is the method of construction, large sized glass sashes should be placed in the front to give the sunshine access to the building.

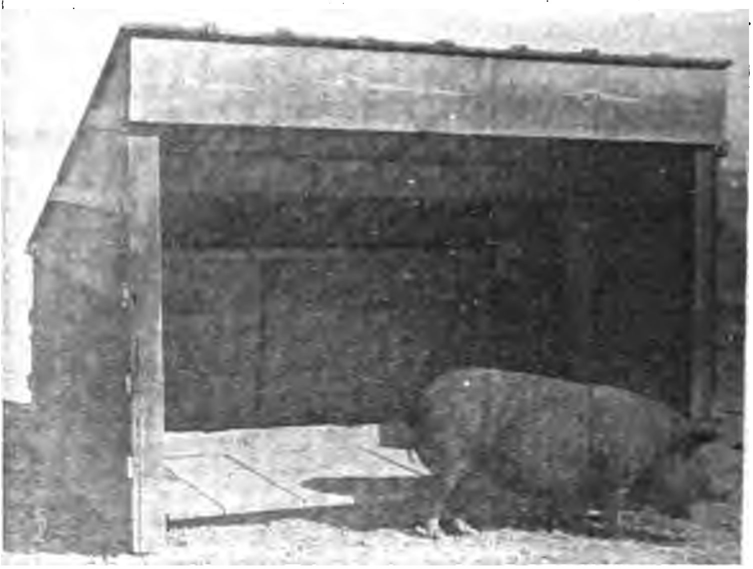


FIG. 5.—Shed Roof Hog House.

The A-shaped house is used especially under field conditions on the Station farm after the sow and her litter are turned to pasture. These houses can be moved conveniently from one pasture to another and thus be used on any part of the farm. The small portable houses have an advantage over the combination houses, as they can be placed in any field on the farm and thus prevent the spread of contagious disease. This type of house, while not as convenient as the combination house, has every advantage from the standpoint of sanitation. It is a well-known fact that hogs will thrive better when partially isolated than when confined in large droves and closely penned. The colony system makes it much easier to keep the premises clean and sanitary, as disease germs and filth are not so likely to accumulate under such conditions. It has the advantage also of allowing the droppings to be uniformly distributed over the farm. It is especially desirable to have the large combination hog-house for use at farrowing time in those sections of the country where the climate is rigorous, and the young pigs require constant attention. Where the sows are close together in a house of this type conveniently arranged, one man will be able to care for a large herd, whereas, if they are widely separated, the work required to care for them is much greater. Under North Carolina conditions it is not necessary, however, to provide such an expensive building, as the individual farrowing pens will serve every purpose if careful attention is given to the details of construction and arrangement.

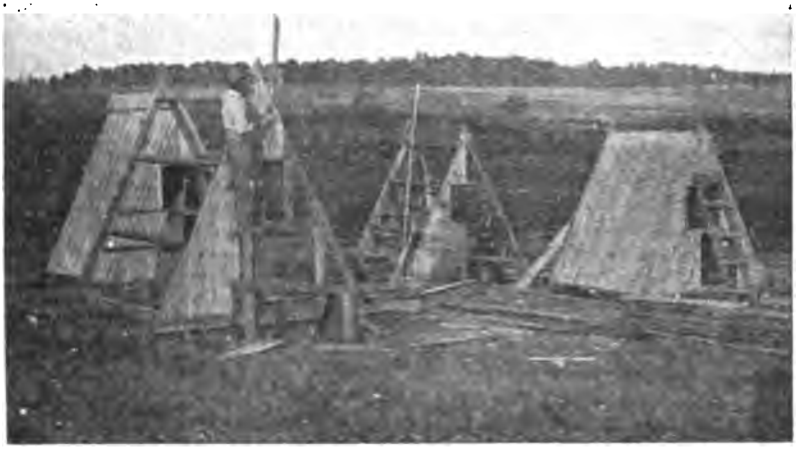


FIG. 6.—Constructing the A-shaped Hog House.

The illustration (Fig. 7) showing an A-shaped house is a good example of a simple practical shelter for the less rigorous southern climatic conditions. This type of house is in constant use on the Station farm, both winter and summer, and it serves our purpose admirably and is comparatively inexpensive to erect and maintain. These houses may be built with permanent skids under them ready for moving at any time, but it is probably a wiser plan to use a temporary form of runner, as the permanent ones will rot out in time and necessitate repair at considerable trouble and expense.

With the temporary skid, this objectionable feature is eliminated. During the fall months when the hogs are being fattened for market, several of these houses may be moved into one lot, and used as shelter for large shotes. By providing several shelters of this kind, fat hogs are not so likely to pile up and suffocate as where one large shed is in use.

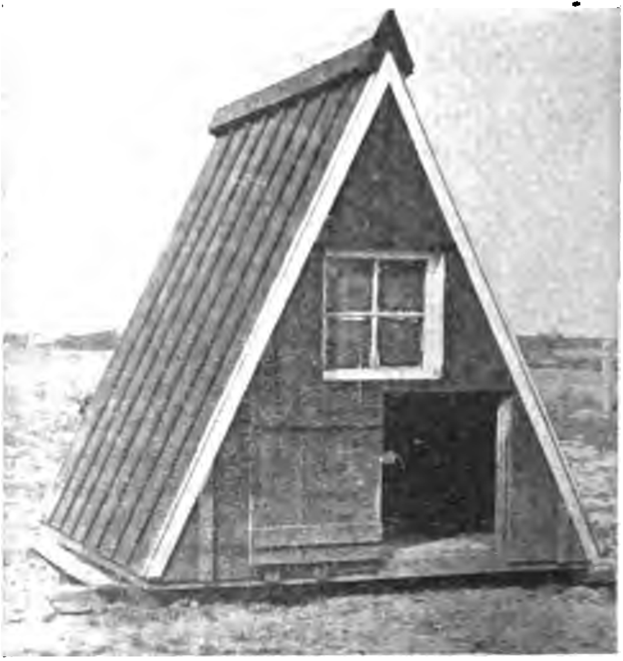


FIG. 7.—The A-shaped Hog House.

PASTURES AND FENCING.

It is not a wise practice to undertake raising hogs on a commercial scale without proper pasture and fencing material, as the hogs should be divided into lots according to age, size, and sex, otherwise the large ones crowd the small ones away from the feeding troughs, which results in a number of stunted pigs; or in the case of males and females in the improper control of the breeding animals.

The fences may be constructed of twenty-six inch woven wire fencing which usually can be purchased for forty to forty-five cents per rod. With wire of this kind one post every twenty-five feet will turn hogs satisfactorily. While this material is rather expensive on the start, a good galvanized wire fencing will last indefinitely and more than repay for itself in a few years.

It is of practical necessity to have one quite large hog pasture where dry sows or shotes may be turned, and there glean a considerable portion of their livelihood. In the corn-growing states it is becoming quite common for the farmers to fence the entire farm and thus utilize their crops at any time when occasion calls for this system of management. Standard wire fencing material will not need to be replaced for a comparatively long time, and the extra hogs, and healthy surroundings prevailing under such circumstances will go a long way toward paying for the equipment. Many farmers who are using this system speak highly of the practicability of it and would under no circumstances undertake to manage their hogs without it.

If the pastures are large and well fenced, hogs will seldom, if ever, give trouble by crawling under the wire. The secret of this system of management is that the hogs are surrounded with conditions quite similar to those which existed in their natural habitat.

BREEDING CRATE.

The breeding crate is a practical necessity on a farm where a large, heavy male heads the herd, and where immature females are

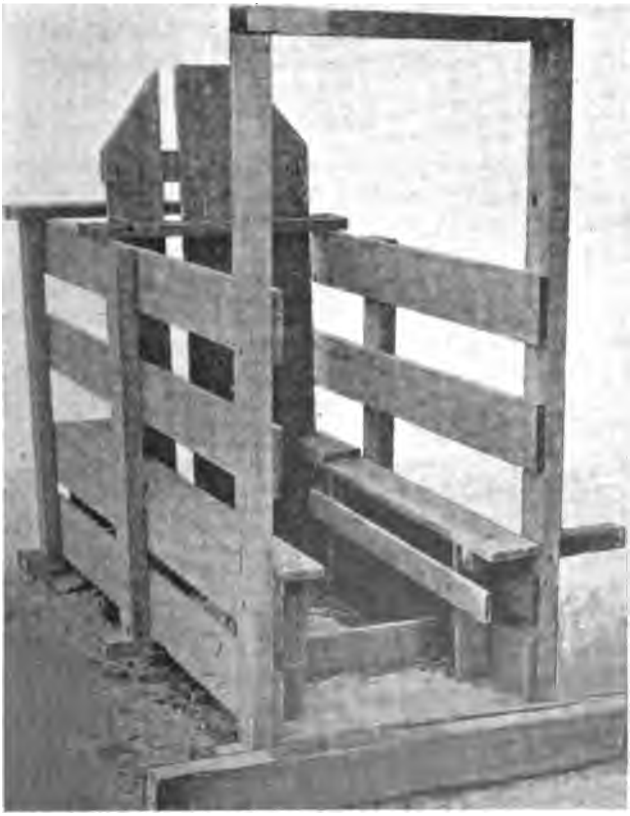


FIG. 8.—Breeding Crate.

added to the breeding herd each year. It is not necessary to provide the crate for strong, mature females unless a young boar is used. In this instance, the females may be so much larger that some device must be used to raise the boar to a height sufficient to allow him to serve satisfactorily, and thus insure conception. The breeding crate may be purchased with a device for raising and lowering the male to accommodate the female, and also an arrangement to sustain the weight of the male from young sows during service. The home made crate, however, can be arranged to provide for females of large or small size, and to sustain the weight of the large mature male.

In Fig. 8 is shown a home made crate which any farmer who is handy with the hammer and saw can construct in one day, and the labor and material need not cost more than three dollars.

While it may not seem necessary to provide this artificial arrangement for breeding young sows, the wisdom of it will be fully emphasized after a valuable young female is made prematurely useless by subjecting her to the weight of an amorous male. It is possible that a crate will not be used more than two or three times during the year, yet its use during one service may save many times the original cost of the device.

BEDDING.

Bedding material should be furnished in comparatively small amounts and should be applied often. When a large quantity is used a considerable portion of it is wasted, as the hogs trample over it and contaminate the extra amount which must be removed when cleaning and disinfecting is done. Large quantities of coarse, stiff bedding given to the sow at farrowing time is especially objectionable as the pigs may become entangled in it and failing to extricate themselves, may be overlaid by the mother. This can be avoided by providing smaller amounts of fine, clean bedding at frequent intervals. Such a plan is more economical; there is less chance of disease germs breeding and not the same element of danger with the pigs. Bedding is in many instances quite expensive, and should therefore be used judiciously, carefully saving all the manure which accumulates from its use.

Probably the best and most plentiful material for bedding is pine straw. This is naturally an ideal material as it is short, fine and thus not likely to entangle the pigs. It has strong disinfecting qualities in the turpentine which it contains, making it one of the best natural bedding materials under southern conditions, and where large quantities are at hand, it should be used especially for sows at farrowing time.

Fine, dry pine shavings are sometimes used. Wheat straw and rye straw are good if properly prepared either by cutting or breaking into fine portions. For large hogs this is not necessary, but for small pigs it is dangerous to allow them with the mother in a bed of very coarse straw. Apparent kindness in filling the farrowing pen with such material may be the cause of great loss with young pigs. Refuse corn stover if dry and clean makes a good bedding material for shotes, and even for young pigs, if properly prepared.

Under ideal conditions, the bedding material should be removed from the houses each week or at least every two weeks and the pens thoroughly disinfected. After the houses are disinfected, they should be thoroughly exposed to the air and sunshine to dry them out before new bedding is given. This is important, for if the dry bedding material is placed on a damp floor, it makes very undesirable sleeping quarters. Such a condition provides an admirable place for disease germs to accumulate and breed. Pigs are also very susceptible to dampness, which often causes much annoyance and loss from rheumatic troubles. Careful attention in providing dry, warm beds for the sows during the farrowing season, and for the weanlings during the colder months will usually avert considerable loss.

COMBINATION OF FEEDS.

Feed-stuffs are classified as nitrogenous and carbonaceous. The nitrogenous feed-stuffs are used by the animal body for the production of muscle or lean meat, and to a small extent for the formation of bone. The carbonaceous feed-stuffs are used for the production of heat, energy and animal fat. In compounding a ration, therefore, the feeds should be combined in such a proportion that they will form a balanced ration, that is one which contains the body requirements of protein, carbohydrates and fat. It is not a difficult matter to provide this under southern conditions because of the great variety of feeds which can be grown. From the time the pig is a mere weanling until he is ready for the market, it is not necessary for the ration to be unbalanced as both nitrogenous and carbonaceous feeds can be grown in abundance. It is not the intention to give the impression that commercial feeds can not be used profitably, although they should not be used to a large extent especially after the pigs have been weaned. Field crops should be provided for the pigs when they arrive at this age, and a comparatively small amount of commercial feeds used thereafter.

For the brood sow suckling pigs in the spring, the following ration will give good results:

Corn meal	4 pounds.
Soja beans	2 pounds.
Wheat middlings	1 pound.

The feeds composing this ration should be thoroughly ground, with the exception of the middling, mixed dry and moistened with enough water to make a slop which will pour freely. The soja beans and wheat middlings provide the protein, and the corn meal the carbohydrates. Aside from this, it is well to feed some shelled corn to the pigs in order that they may learn to masticate their feed early in life. A green grazing crop should always be provided, such as fall rye, Canada field peas and oats combined, or rape, all of which will materially aid the sow in providing milk for her litter.

The ration given above and the comments following are intended only to serve as an example concerning the combination of feeds to furnish a balance of nutrients. The following ration is also suited for a sow suckling pigs:

Corn meal	4 pounds.
Wheat middlings	3 pounds.
Tankage	1 pound.

The wheat middlings and tankage furnish the protein and the corn meal, the carbohydrates. Corn is one of the feeds most commonly used in the ration for swine, but it is safe to say that under southern conditions there is never a time when it can not be supplemented with a nitrogenous feed profitably. Some of the more common feeds for this purpose will include cowpeas, soja beans, wheat middlings, oil meal and tankage. These are all concentrated feeds and should be fed largely in the form of a slop. The nitrogenous roughages used for balancing a carbonaceous ration include those commonly grown for grazing crops, such as cowpeas, soja beans, vetch, clover, Canada field peas and alfalfa.

It is very important in preparing for these crops to grow only those which are adapted to the soil and climatic conditions of the section of the state in which the farmer resides. The same might be said of the commercial feeds, as it is highly important to select those feeds which contain the largest percentage of protein at the least cost per pound. The palatability and digestibility of the ration is an important consideration also, as feeds which are not relished by hogs will not ordinarily make profitable gains.

SELECTION OF FEEDS.

Feeds should be selected according to their availability, market price and efficiency in producing growth or fat. Home-grown feeds should be used generally when it is possible to produce them on the farm. Commercial feeds, while necessary in certain instances, are limited in quantity, and always command a price which makes them almost prohibitive except for the purpose of balancing highly carbonaceous rations. They should never be used as the basal part of the ration, but rather as supplementary feeds. In purchasing the supplementary feeds, only those should be used which have given general satisfaction in swine feeding. It is extremely important to consider their palatability, since their actual composition does not always portray their real practical feeding value. For example, cotton-seed meal is a very rich commercial feed, yet its use in rations for swine is hazardous except within narrow limits. While this is an exceptional case, yet in many instances feeds apparently valuable do not return satisfactory results in practice.

Fortunately the geographical location of North Carolina, and the conditions prevailing therein are well suited for growing feeds at home which are especially adapted to the development of the swine industry. The crops suitable for swine include oats, rye, wheat, cowpeas, Canada field peas, soy beans, crimson clover, rape, vetch and a combination of these crops, such as oats and rape, oats and vetch, rye and rape, and oats and Canada field peas. These crops may all be easily grown if proper provision is made. The other important crops include Bermuda grass, Japan clover, peanuts, chufas, sweet potatoes, artichokes, mangels and turnips. All these crops are relished by swine, and can be harvested by the hogs in the field except in a few cases.

There is very little necessity, in fact, for the farmer to be burdened with the selection and purchase of commercial feeds, and when it becomes necessary, due consideration should be given to this task, as feeds vary considerable in their important constituents. The quantity of feed secured in too many cases is the guide in selecting, whereas the quality should be given first consideration. When the farmer buys a commercial feed, he as a general thing buys the protein in the feed, consequently that feed should be purchased which contains the most protein for the least money, due consideration being given to the adaptability of the feed.

During the suckling stage, the pigs are ordinarily fed corn meal, wheat middlings, or some other concentrated feed which will make a palatable, nutritious slop for the mother and her litter. From the time they are weaned, however, the farmer should grow practically all the feeds necessary for their proper growth, unless he purchases some highly nitrogenous feed to balance the corn. For this purpose, tankage has given general satisfaction, and it may be used when it can be secured at a reasonable price.

Generally speaking, the farmer can better afford to raise his own crops than depend on commercial feeds. The more common commercial feeds used for balancing the corn ration are wheat middlings, linseed meal and tankage. Whether commercial feeds can be used profitably will depend on local conditions. If the animals are to be sold as breeders for fancy prices, larger amounts of commercial feeds may be used with satisfaction and profit.

Packing house by-products used for feeding purposes usually contain large quantities of protein, and relatively large quantities of bone making material which makes them popular with breeders of pure bred swine. It is seldom, if ever, however, that they can be used in practical pork feeding operations, except in very limited quantities for balancing highly carbonaceous feeds.

PREPARATION OF FEEDS.

It is not a general practice to cook feeds for swine. In the first place it is questionable whether any favorable changes take place in the feed by cooking, and if so, whether the extra gains pay a profit on the labor and expense required to prepare the feed in this manner. Experimental data shows also that the nitrogenous portion of the ration is rendered less digestible by cooking. If at any time the cooking of feed is beneficial, it is in the preparation of such feeds as potatoes and mangels or other starchy root or tuber crops.

In the colder States with the larger breeders and feeders, there may be some excuse for making special preparation of feeds, but with the Southern farmer, who has a mild climate and long growing seasons, there seems to be little necessity for this extra care and expense. The soaking of feeds such as corn and other whole grains is quite often beneficial. This requires a relatively small amount of trouble, however, and may be followed with satisfactory results. One of the secrets of successful hog-raising in the South is to provide abundant field grains and grasses and allow the hogs to do their own harvesting.

NECESSITY OF PROTEIN AND ASH.

Probably one of the most neglected phases of swine feeding is the failure to supply sufficient protein and ash in the ration. This is commonly true with small farmers who have not taken the time to inquire regarding the needs of a hog during the various stages of life. Protein and ash are especially needed by the animal while the body is in a growing condition. The reason for this is evident when consideration is given to the needs of the growing animal. The bone is composed largely of calcium and phosphorus—ash materials—which must of necessity be supplied in the ration, else the bony framework does not attain its normal size. Likewise, the protein, which goes largely to build up muscles, must be given in the ration, or the body does not attain that full symmetrical development so much desired in the mature animal. When these two nutrients are withheld, the body is dwarfed in size, and afterward, no matter how well the animal may be fed, the normal growth can not be attained.

Until recently, sufficient emphasis has not always been placed on ash requirements. It must receive due consideration, however, as one of the most vital periods in the growth of the pig is during the stage of bone formation, upon which proper maturity so largely depends. After maturity, the quantity of ash needed is not so great, as the main requirements of the latter stage is material simply to supply the waste tissues. During the former stage, material must be provided for growth and for building up waste tissues. After maturity, the repairing of the waste tissues of the system, and the conditioning of the animal only need attention. This accounts for the fact that corn can be used fairly satisfactorily during the fattening stage. The bony framework is fully developed, the muscles are completely formed, and the one thing now for the feeder to accomplish is to put the hog in high condition for market, which requires a relatively large amount of fat producing feeds as compared with the ash and protein requirements.

SUCCESSION OF FORAGE CROPS.

Forage crops should form a considerable part of the ration for swine: (1) because of their beneficial effect upon the digestion of the animal; and (2) because of the larger and greater economy of gains secured. The value of these crops is not fully realized by farmers generally, or greater use would be made of those which can be grown so abundantly. It is especially important also that more leguminous crops should be grown to improve many of the worn-out soils of the State. There is one exception, however, where green grazing crops can not be used profitably for a swine feed, and that is during the final fattening stage. At this time, the ration should consist largely of concentrates, as the harvesting of bulky feeds would tend to retard the gains. During the growing stage of the pig, however, pasture and exercise are very essential. A hog which is kept in a small, filthy, unsanitary pen from birth until maturity makes unprofitable gains, and in general makes the swine industry unsatisfactory to the man who follows such a practice. The hog should be allowed the privilege of gleaning half his ration from pasture crops. Supplement these pasture crops with other feeds, preferably those which are dry and concentrated. Such a practice will insure good results, giving opportunity for exercise, sunshine and a natural freedom from disease.

The majority of the crops in the following rotation have been used successfully on the Station farm during the last two years. The amount of forage necessary to provide will depend on the size of the herd and the productivity of the soil. The time of seeding will likewise depend on the needs of the farmer, the particular crops fitted into the rotation and the nature of the soil. The time for seeding and grazing will vary considerable, the exact dates being governed by seasonal conditions. By selecting from this list of crops those which are suitable to the soil and climate, and the particular needs of the different individual farmers, grazing may be supplied practically during every month in the year. It is important to consider carefully the adaptability of the crops, as the conditions in the State vary so greatly that it would be practically impossible to furnish a rotation of forage crops suitable to all sections. It will be noticed in this succession that there is some overlapping of crops, but this is a wise practice, since it is better to figure on an over-supply rather than to have a shortage. Whatever remains unused by the hogs may be plowed under to furnish humus to the soil, or after maturing

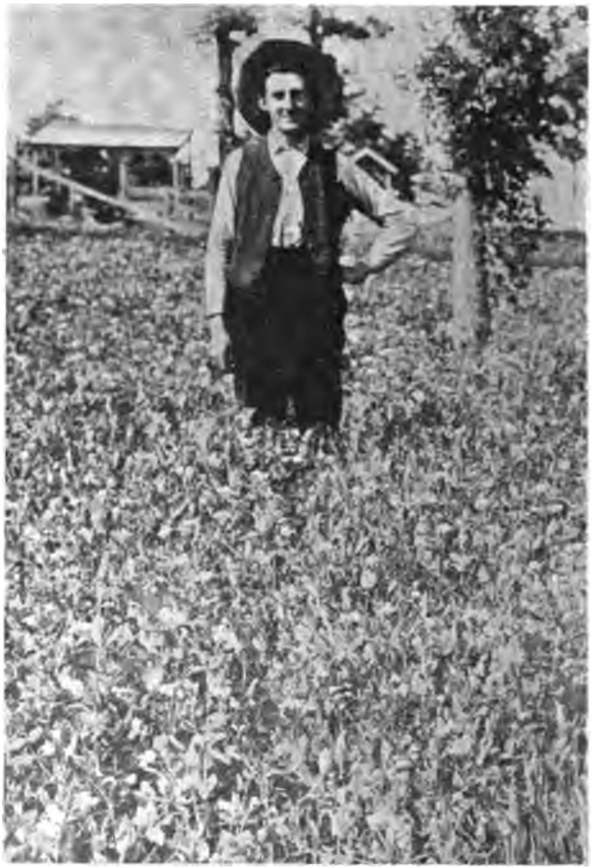


Fig. 9.—Canada Field Peas and Oats.

properly, it may be cut for hay. Variations of soil and climate will determine to a large extent the rotation. Those crops should be used which are especially adapted to the general farm conditions of the section.

The variety of cowpeas to use in the rotation will depend on the object in view. If an early crop is desired, the New Era will give good results. Clay and Unknown peas may be used for later crops. Rape should not be sown during May, June, July, and the first half of August for best results. Red clover is not well adapted to the eastern or lower Piedmont sections of the State, but in the mountains it can be used advantageously. If burr clover is sown on Bermuda grass sod in the fall of the year, the two crops will furnish a large amount of feed as they alternate, the Bermuda coming on in the summer and the burr clover in the fall and winter.

The table following gives the date and rate of seeding and the approximate time at which grazing will begin and end:

FORAGE CROPS.

Kind of Forage.	Seed per Acre.	Date of Seeding.	Period of Grazing.
Rye	1½ bushels	August 1 to December 1	October 1 to April 20
Rye and Crimson Clover	1 bushel 15 pounds	August 1 to October 1	November 15 to April 25
Oats	1½ bushels to 2 bushels	September 10 to November 15	November 1 to July 15
Wheat	1½ bushels	September 15 to December 1	November 20 to July 15
Oats and Vetch	1½ bushels ½ bushel	August 10 to October 1	November 15 to April 20
Cowpeas New Era	1 bushel	May 15 to July 15	July 10 to October 15
Soy beans	1 bushel	May 15 to July 15	July 15 to October 15
Canada field peas and Oats	1 bushel 1 bushel	February 15 to March 1	April 15 to June 15
Alfalfa	30 pounds	September 1 to October 15	May 20 to September 20
Bermuda grass	Rootstalks every second round of plow	March 15 to May 15	June 1 to August 15
Spanish peanuts	2 bushels in hulls	May 15 to July 15	September 1 to December 15
Sweet potatoes	10,000 plants to acre	May 1, to July 1	September 15 to December 1
Mangels	4 to 5 pounds	April 20 to May 15	October 15 to January 1
Chufas	2 bushels	April 1 to May 10	September 15 to January 1
Artichokes	3 to 5 bushels	November 1 to February 20	November 1 to March 1
Burr clover	20 pounds clean 40 pounds burr	September 1 to October 1	December 1 to March 1
Red clover	15 pounds	September 10 to October 15	April 1 to June 15
Japan clover	25 pounds	April 1 to May 15	June 1 to September 15
White clover	5 to 8 pounds	September 1 to October 1	December 15 to June 1
Rape	6 pounds	August 15 to May 1	Eight to ten weeks from seeding

VALUE OF CORN.

Corn, while one of the principal crops grown in the State, is often used to excess and to the detriment of the farmer and the hog industry. At the present price of corn, it makes an expensive ration, and considering that other feeds less costly will prove more efficient in pork production, it immediately resolves itself into a business proposition which no farmer can afford to ignore. It will be remembered, however, that corn alone is not well suited for hogs during the growing period. On the other hand, a ration composed largely of corn is very desirable after the hogs are ready for the fattening pen. With this one exception, an economical feeder will eliminate it to a large extent from the ration.

Corn is preeminently a fattening feed, and it should be given in large quantities only when the hog has arrived at the proper stage for making economical use of it. Its heating and fattening properties make it an unbalanced ration for the growing animal, and careful feeders use it with great precaution. It is probably one of the most abused farm feeds, simply because it is widely grown and apparently relished by all animals. Its extensive use accounts in a large measure for the small-boned, poorly-fleshed animals used for breeding purposes, a condition which materially decreases the profits to the swine grower. Other feeds which are cheaper and more efficient should be substituted in part for corn. This can be done by furnishing a succession of forage crops, and exchanging corn for feeds which contain a relatively large amount of ash and protein. At the present market price of corn, there is greater need for buying nitrogenous concentrates than when the price is exceptionally low. This fact always holds unless the price of commercial concentrates becomes prohibitive, in which case it may become more economical to feed corn alone. It is hardly possible, however, that such conditions will arise, as corn in the South rarely sells below eighty or ninety cents per bushel. Under such conditions it is generally wise to sell corn and buy concentrates for balancing the ration if they are not produced on the farm. It is impossible to grow hogs and develop them properly on corn alone, as the nutrients are not combined in the right proportion to make the proper growth of bone and muscle in the growing animal.

DAIRY BY-PRODUCTS.

When conditions permit, dairy by-products such as skim-milk, buttermilk and whey should be fed to swine, as they are very beneficial in balancing a starchy corn ration. If used for feeding purposes, they will probably give better results with swine than with other classes of animals, except possibly with poultry. It may be possible that a man is so situated that he can use these by-products more profitably by manufacturing them into other salable products, such as skim-milk buttermilk and cottage cheese. It is largely a question of circumstances, how best to utilize these products. If there is greater profit in manufacturing them into human food, then the farmer is manifestly justified in doing so. There is, however, in warm sweet milk just the kind of nourishment which makes the strong, thrifty and large-boned pigs which are so useful for breeding purposes, and it is extremely doubtful whether these by-products could be used more profitably, if breeders' prices are obtained for the hogs.

Dairy by-products not only play an important part in furnishing food material, but they stimulate more profitable consumption of other feeds in the ration. Skim-milk, for example, contains about ten percent of digestible dry matter, while corn contains nearly ninety percent of digestible dry matter, yet in rating the value of skim-milk, six pounds is ordinarily credited as having the same feeding value as one pound of corn. This is an important point, as it is thus seen that the feeding value of skim-milk is not rated entirely on the dry matter which it contains. Silage for dairy cattle, while considered indispensable in the ration for best results, has a value besides the actual dry matter content. Its use as an appetizer and in the promotion of the digestion of other feeds is very important. If a succulent feed is available, it should constitute part of the ration. In the case of skim-milk for hogs, from five to six pounds of milk should be substituted for each pound of grain normally used in the ration up to the capacity of the animal for using a watery feed of this nature. The digestive capacity of the animal is comparatively limited, consequently the entire ration could not consist of a feed containing such a large quantity of water. For young pigs, the ration may consist largely of milk, until greater quantities of feed are required to keep the body growing. At this time a concentrated feed should be substituted in part for the milk in the ration.

Buttermilk and whey are not as valuable as warm sweet milk, yet they can be used advantageously. Buttermilk while containing as much dry matter as skim-milk can not be fed in a form relished by the pigs as can skim-milk fresh from the separator. Whey contains only six per cent of dry matter, and it may be used to a limited extent.

Dairy by-products as a whole should be carefully saved, as their effect on the efficiency of the ration is very important. The value of skim-milk especially is widely known and whenever it can be procured in a sweet, wholesome form at a reasonable price, it may be used to a decided advantage in replacing high-priced corn. The bone of a hog which has been fed skim-milk is large and strong, consequently pigs which have been fed on skim-milk make most desirable breeding animals.

KITCHEN WASTES.

It is a common practice with farmers who live near the cities to use the kitchen waste from the hotels and boarding houses. These feeds may be used in moderate quantities, provided they are fresh, are hauled in clean barrels, and contain none of the washing powders which are used in the dish water. There is without doubt a large number of hogs killed each year from the effects of the greasy slime and washing powders which gain access to the receptables for these hotel wastes. When fed in a pure form and combined in moderate quantities with other feeds, these wastes contain a very large amount of nourishment. The scraps of bread and meat especially will produce growth in an astonishing manner. This is not surprising, however, since the character of these foods furnish the required nutrients for an efficient ration. They furnish a valuable and usually a cheap feed when fed in moderation, but only the pure scraps as they come from the table should be used.

AGE TO FATTEN FOR MARKET.

The marketing of hogs is really a fundamental business proposition which every farmer must solve for himself. As a general thing entirely too many hog-raisers do not give this subject proper thought and care. A successful hog-grower must necessarily know how to buy, feed and market his stock. Lack of good judgment in any of the three operations may mean failure in the business.

The fattening hogs should be started uniformly on their rations and kept growing steadily until the proper weight has been attained, which should range from two hundred to two hundred and fifty pounds or even lighter if prime bacon is the object of production. The former weight should be attained in six to nine months with well-bred hogs properly managed. For the first six months, the shotes should average one pound of gain per day. This should be the standard set by the progressive feeder, and if it is desired to hold the hogs for more weight, eight or nine months should be sufficient to bring them up to the two hundred and fifty pound mark. The old system of feeding for eighteen months or even two years has been discontinued long since by the most successful feeders. The cost of production, the change in market demands and the hazard connected with the system have materially altered the conditions.

The aim of the feeder should be to market the fat hogs after they have made their most profitable gains, which will be at six to nine months from birth. While it may not be possible in some instances to have the hogs up to standard weight at this age, however in the majority of cases experienced feeders can do so and even better under proper conditions.

The primary law of nutrition can not be varied except under markedly altered conditions, consequently, uniform gains and early maturity govern economic production and marketing of hogs. A few years ago it was not an uncommon thing for farmers to market their hogs at eighteen months to two years of age, at which time they weighed from four to six hundred pounds. At that time, however, the packers could use a hog of this type much better than at the present time. The market is calling for a smaller, leaner type of hog suitable for use without excessive trimming. This change in market demands has been a boon to farmers in several ways, as the large five hundred pound hog is made at a much greater cost per pound of gain than the two hundred pound hog. This is a fact which is fundamental in all live stock feeding and a principle with which every farmer should be familiar. As the animal increases in weight, the daily work of the body increases and therefore more feed is required to keep the body in repair. It is only after this function has been performed that gains will be made, and as the capacity of the hog is comparatively limited enough feed can not be consumed by the larger animal to repair the waste of the body and make the rapid gains that were made during the earlier growing period.

Again large hogs may become crippled or diseased and thus be a very significant loss to the owner. This is quite important in the mind of the writer. In several cases that have come under observation, disease has gotten into the herd and destroyed a large percentage of the animals when if they had been marketed a few weeks previous when the herd was in a healthy condition, this loss could have been avoided. It is true that these troubles can not always be forecasted, yet in the majority of cases, it pays to market medium-sized hogs rather than to feed longer for excessive weight and be caught by the ravages of disease. Good judgment will direct when to fatten hogs for the market. The aim should be to have the hogs ready at a season when high prices generally prevail. Small hogs sell better always during the summer season, and if the crop intended for this purpose can not be disposed of satisfactorily, they should be carried over and fattened for the early fall market. As soon as the packing season opens, the demand increases quite rapidly and thus provides for ready sale of hogs which are in market condition. From then on until well along in the spring months the demand for the larger type of hog will be greatly increased.

EARLY MATURITY.

In selecting a hog for feeding purposes, an early maturing animal should always be given first consideration provided the other qualities are up to standard. It has been fully demonstrated by experimentation and by practical feeders that the market hog which reaches maturity in six or eight months is the most profitable animal. The gains which are made during the earlier growing period are always made at a less cost than those made during the fattening period. A hog which does not mature to a marketable finish until twelve or fifteen months old is usually unprofitable. As a general thing, an excessive amount of feed is consumed during this long growing period and the risk necessarily is much greater. This system of prolonged feeding prevails on many farms in this State, and too much stress can not be placed on the economic necessity of eliminating these undesirable types of swine and substituting the early maturing hog, which would eventually revolutionize the hog industry. A hog properly bred and fed should weigh at least one hundred and eighty pounds at six months of age, yet the writer has seen many animals on North Carolina farms which would not attain this weight when twelve or fifteen months old. Such a condition should not obtain. Generally late maturing animals come from inferior breeding stock, lacking in prime quality, or else from improper care and management.

OBJECTS AND METHODS OF FEEDING.

It is a fact that many feeders do not differentiate in their system of feeding, growing and fattening hogs, yet it should by all means be done. While the animal is growing, or developing bone and muscle, those feeds should be used which are conducive to the growth of these parts. In many cases a highly carbonaceous feed is used which holds the normal growth in check and thereby severely reduces the value of the animal either as a feeder or breeder. Fat is not needed at this early stage in life, in fact it is a positive detriment to the animal except in comparatively small amounts. During the growing stage, nature demands feeds which contain ash and protein, the bone and muscle developers, while carbonaceous feeds are needed during the fattening stage. A feed which does not contain what the body demands at the various stages of growth will decrease the final weight of the animal to the extent to which that feed is used. Corn is one of the best examples of a feed, which does not furnish the growing materials in the best proportion for swine. It is exceedingly low in ash and protein and very high in carbohydrates and fat, thus it is evident that it is entirely out of balance for the needs of the growing hog. It is not possible to get a large, bony framework, heavily covered with muscle, from a corn ration, unless some feed is added to the corn to balance the ration or an entirely different feed is used which is better proportioned.

The fattening hogs and those intended for breeding purposes should be separated early in life to induce the breeding animals to keep on growing to the very last. This should not be neglected, as a great many times ill results are obtained at farrowing time simply because a rational system of feeding has not been adhered to during the growing period.

The question concerning the feeding of swine for the show ring is frequently asked, and it may be stated in general that it is not a wise practice for the Southern farmer to go into the business of show-yard feeding. While it is admitted that showing live stock at the Fairs is an ideal way to advertise breeding stock, yet not many farmers are in a position to make a specialty of fitting them for the show ring. For the general farmer, it should be the aim to satisfy the demands for market hogs, rather than to go into the fancy breeding business. The importation of pork, lard and other hog products should not continue, as there is no section of the country better located than North Carolina for the production of pork. It is necessary to pay closer attention to the development of the market hog; also to the fact that it is a bad practice to fatten breeding animals for the show ring. Successful breeders will admit that hogs which have been excessively fattened do not make the best breeders; in fact in some cases they are made prematurely useless. A breeding animal, to do its best work, should be kept in a medium condition the year around.

COST OF PRODUCING PORK.

The cost of producing pork under Southern conditions is in a great many cases materially increased by improper methods of management. In the first place, not enough range is allowed to mature strong-boned, thrifty pigs; little or no forage is provided, and to make up for this marked deficiency more of the high-priced marketable feeds must be used. This is a wasteful practice and one which must be discontinued before the maximum profits from hog-raising can be realized.

Under farm conditions, pork should be produced for three and one-half to four cents per pound gross. This has been amply demonstrated by the experimental work carried on at the Alabama Station. Their cheapest gains were made with corn and soy bean pasture at a cost of $1.96 per hundred pounds. With corn and peanut pasture the gains were made for $2.28 per hundred pounds. The one striking thing which was brought out was that the cheaper gains were made by the hogs on pasture and especially those on leguminous crops. This fact is of great importance, since the leguminous crops are soil improvers, and in addition they furnished the cheaper gains.

Another striking fact brought out was that every supplement used with corn cheapened the gains. This was true both with commercial feeds and farm-grown feeds, except when the cost of growing the crops was taken into consideration when sorghum and chufa pasture were of no advantage. Other combinations tried demonstrated that it was within the power of the Southern farmer to grow three and four cent pork.

The incompleted work at this Station also indicates that pork can be produced at a cost of three and one-half to four cents per pound. To do this, however, extensive use must be made of the grazing crops. Other Stations have amply demonstrated the feasibility of producing cheap pork, and it is within the range of every farmer to do so by providing suitable grazing crops. Corn should be used sparingly until the finishing period, when, if desirable, the ration can be composed largely of this feed. Up to the fattening period, the hog should be made to harvest a considerable portion of his ration directly from the field. Green feeds can not be used altogether, yet with the addition of a small amount of dry feed, a vigorous growth should be obtained. It would be a conservative estimate to say that at least one-half the ration can be gleaned directly from the field, and in the case of some crops, such as mature peas, beans or peanuts, even more of the daily ration can be so obtained. During the early spring and summer the crops will naturally be more watery and need necessarily to be supplemented with greater quantities of dry feeds than otherwise.

The cost of producing pork will be governed largely by the individual farmer. If ample provision is made for grazing crops, and the other feeds are largely home grown, the cost of producing pork can be reduced to a very low figure under practical conditions.

HEALTH AND SANITATION.

In the management of live stock, swine especially, it is far better to maintain the health of the animal than to use nostrums and various other so-called curative measures. The hog does not respond well to treatment, and it is for this reason that special care should be taken in preserving the health. When a hog once becomes sick with a disease at all dangerous, the chances for recovery are usually small. Hog cholera is one of the most fatal diseases which commonly affects swine, and every precaution should be taken to prevent its occurrence in the herd. Remedies for this disease should be avoided with the one exception of the serum which is being manufactured by the U. S. Department of Agriculture, and the various Experiment Stations. This, however, is not a cure for hog cholera, but rather a preventative which, if used in the incipient stages of the disease, will in most cases save a large percentage of the herd.

A system of management whereby the hog lots, pastures and houses can be kept in a perfectly sanitary condition is one of the vital things for the swine husbandman to consider. A great many diseases common to swine are brought about through improper sanitation. Disease germs breed in filth. Sunshine and pure air are their enemies. Therefore the first essential is to provide for the hogs so that they will naturally keep clean. This necessitates wide range, as hogs kept in close confinement will soon get their enclosures in an unsanitary condition.

Provide an abundance of pasture, preferably divided into several lots, such that the hogs can be kept in small droves of fifteen or twenty. Do not allow water to collect, as a wallowing place will result and serve as a breeding place for disease germs. Plenty of fresh, pure water should be provided for this purpose if shade is not available. This is especially necessary during warm weather, yet if sufficient shade is provided in the pasture even the water may be dispensed with except for drinking purposes. Dust wallows, like water wallows, are undesirable, as they are naturally unhealthy, causing excessive coughing, irritation of the lungs, and possibly disease, as they become polluted by the excretions from the hogs.

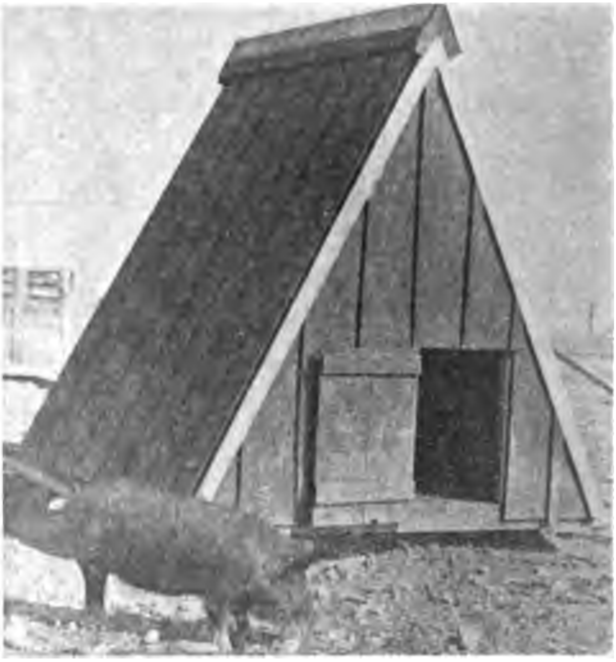


FIG. 10.—Conditions Right For Farrowing.

Fresh air-slaked lime scattered freely about the premises is a good disinfecting agent. Once or twice each year it is an excellent plan to go over the lots and pens scattering fresh pulverized lime on the ground, feeding floors and in the houses. The inside of the farrowing pens can be made fresh and clean by applying a coat of whitewash on the walls and ceilings. This is an inexpensive method of disinfecting and yet a very effective one.

When disease breaks out in the herd, the healthy hogs should be removed to clean quarters, as it is possible to prevent considerable loss by so doing. All dead animals should be carefully burned or buried, as it is not always possible to determine what may have caused their death, consequently every precaution should be taken.

A mixture of the following materials will be relished by the hogs, act as a preventative of intestinal worms, and create a keen appetite; wood ashes, 60 pounds; charcoal, 60 pounds; air-slaked lime, 20 pounds; sulphur, 15 pounds; salt, 2 pounds; turpentine, 2 quarts; copperas, 10 pounds.

Keep this mixture constantly before the hogs, preferably in a self-feeder under cover.

If a contagious disease gets into the herd, make every effort to stamp it out. Do not allow visitors to frequent the farm, because of the danger of spreading the contagion to other parts of the premises and possibly to a neighboring farm. When a new lot of hogs is purchased, they should be quarantined for three weeks or more. They should never be placed with the herd immediately, as some disease may be on the verge of breaking out in the newly purchased animals. By observing these precautions, it may effect a great saving in the herd.

DEPRAVED APPETITES.

The depraved appetite is an indication that the ration is lacking in some important food nutrient. This is generally ash or protein, or both. Corn is one of the most common examples of an ill-balanced ration and hogs fed on it exclusively, especially growing hogs and breeding females, exhibit marked tendencies toward disturbed nutrition. Corn is highly carbonaceous, and the growing hog needs considerable ash and protein. The common indications of an improperly balanced ration are the eating of sand, clay, rocks, gravel, rooting for worms and roots. The growing hog quite commonly exhibits these symptoms and often the brood sow when fed on a sole corn ration becomes feverish and greedily devours her pigs in an effort to satisfy the peculiar hunger for the lacking nutrients. Correctives for this condition can not be used with the expectation of securing immediate results. If rational feeding is followed this abnormal condition will not appear. Should it arise, it means a setback which probably can not be entirely overcome during the life of the pig.

CONTAGIOUS DISEASES.

Hog cholera and swine plague are the two contagious diseases which every swine breeder must guard against, and to this end prevention should be depended upon rather than cure. Every possible means should be used to prevent an outbreak by keeping the premises clean and sanitary and in preventing the transportation of the disease from neighboring farms. There should be no refuse matter left in the feed troughs that will attract scavengers.

The writer has in mind several cases where the feeding grounds were exposed to the visitation of buzzards and for several years in succession practically the entire herd of swine on this farm was destroyed by cholera. The origin of the outbreak each time was in all probability on a near by farm where cholera was quite prevalent. Without doubt the disease was carried from this farm each year to the neighboring farms where cholera occurred regularly. Cleanliness is one of the first safeguards in avoiding these attacks, although it is not an absolute preventative. The price of one hog spent for disinfectants, and the time consumed in cleaning up and thoroughly applying the disinfectant may be the means of saving the entire herd.

It is a good plan to change the hog pastures and lots occasionally. This is one great advantage of growing annual crops, as this practice will have a material influence in renovating disease infested soil. In the South, in fact, it is generally necessary to rotate the crops to maintain the hog pastures continuously, and from the standpoint of sanitation this is a fortunate condition. This is the practice followed on the Station farm, and the results have been very encouraging considering the continued healthy condition of the herd. While cleanliness may not have been the sole reason for this, yet cholera was quite prevalent on near by farms for several successive years.

HOG LOUSE AND DIPPING TANK.

Every farmer who raises live stock, and especially hogs, should provide himself with a dipping tank. The cost of a tank for dipping hogs is comparatively small and the satisfaction of keeping the stock in a clean, healthy condition is worth the original cost of the equipment. On hogs, lice are the only common external parasites, but fortunately they can be destroyed with comparative ease provided proper precautions are taken to keep all lots and buildings well disinfected. This can be done by the use of a spray pump and a five per cent solution of some of the proprietary dips to which has been added two per cent of crude petroleum, which will make the dip more effective. Or, some effective home-made disinfectant may be used, such as whitewash. It is absolutely essential that the lots and pens be kept clean, for if this is not done the herd will soon become re-infected even though the animals are dipped carefully.

The formula for making kerosene emulsion, which is an efficient home-made dip, is as follows:

Kerosene	two gallons.
Water	four gallons.
Hard soap	one pound.

The soap should first be shaved fine and dissolved in hot water, after which the kerosene is added to the mixture and the whole thoroughly agitated for ten to fifteen minutes. This emulsion is then made ready for use by mixing one part of the emulsion with eight parts of water. During the time the emulsion is in actual use, it should be kept thoroughly mixed, as the kerosene may separate and the effectiveness of the dip be destroyed. A small amount of lard or cotton-seed oil added to the emulsion will be very helpful in overcoming any irritating tendency the kerosene might have should it by mistake be applied in a concentrated form.

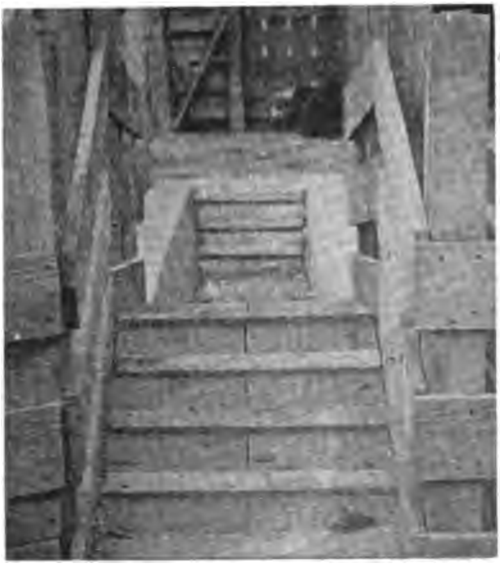


FIG. 11.—The Swine Dipping Tank, a Necessity for Destroying Lice.

Before spraying the lots and pens, the old bedding and refuse matter should be removed and burned, in order that the spray may penetrate and do its work effectively. Cracks and crevices are the common harboring places for lice. The disinfectant should therefore penetrate thoroughly. If only a few of these parasites are left they will reproduce rapidly and the result will be that the animals are soon re-infected.

In the actual construction of a dipping tank, the aim should be to provide for efficient work and still not have the tank so large as to require an excessive amount of dip. If it is properly constructed, the economizing of dip will prove to be quite an item during the season.

The ordinary galvanized iron dipping tank is the one in most common use, but it is not as lasting as a tank built of brick and then cemented, or the solid concrete vat built in a mould or form. This latter tank will cost somewhat more, but will last for a lifetime, and there is no danger of bulging or leaking if the masonry work has been properly done. A tank ten feet long on top, four feet long on the bottom, twenty inches wide at the top and eight inches wide on the bottom, and four and one-half feet deep will answer every purpose. The tank should be set four to eight inches above the ground to keep out surface drainage and filth, the admission of which would weaken the disinfectant, and make it very disagreeable where it is necessary to dip sheep in the same tank. All necessary equipment for dipping should be located convenient to the yards or pens where the majority of the stock is kept. This will admit of more frequent dipping and at much less trouble and expense. A float should be provided at the inlet end of the tank, which serves as a trap, leading the animal to the extreme edge of the dip, when suddenly the weight causes the float to sink, which thus plunges the animal directly into the disinfecting solution.

Many other disinfectants are placed on the market which are comparatively inexpensive and effective if used properly. Generally a two to three per cent solution of these dips thoroughly mixed in pure, clean water will be sufficient for destroying the external parasites commonly found on swine. The management of the herd should be such that the dipping will be done on a warm sunshiny day. If the weather is cold, it will be well to warm the dip to 110° or 112° Fahr., admitting the heat from the bottom of the tank. However, if the herd has been properly managed they need not be subjected to the dipping process during the colder months.

The cost of the dipping tank should not exceed $35, including the excavation, tank and labor for installing the plant. If it is not possible to construct a regular dipping tank, a barrel or tub can be used very satisfactorily for young pigs. It would be rather difficult, however, and even dangerous to dip large hogs under such conditions. It would be much better in this case to apply the dip with a brush or spray, being very careful to reach the armpits, under the jowl, back of the ears and neck, in the flanks and between the legs where the skin is thin and where the lice are usually most numerous.

The ravages of the hog louse will greatly decrease the profits of hog raising unless some means of eradication is devised. It is persistent in its attacks and if the premises are not kept clean and sanitary it will become a constant source of trouble. The hogs should be dipped at least once or twice after the initial treatment to destroy the eggs or nits which have hatched in the meantime. Large numbers of these eggs will be found on the body, and unless the hogs are subsequently dipped, the relief is only temporary.

After dipping, the whole herd should be removed to a clean pasture or lot where hogs have not been allowed to graze for some time. If the lots are plowed and planted to forage crops annually, the lice on the farm can be destroyed much more easily. Also hogs which have been purchased from outside parties should be thoroughly dipped before putting with other hogs, or otherwise they may infect the whole herd again and thus necessitate much extra trouble and expense.

Young pigs should be watched closely as they commonly become infested, and their growth as a result is materially reduced. The vitality of young pigs is often sapped to such an extent that they never completely recover from the effects of this parasite.

INTESTINAL PARASITES.

Fig. 12 shows a portion of intestines taken from a pig weighing twenty-five pounds. The worms had so completely sapped the life of the animal that it was killed as it was quite evident that death would result in a few days. Although this is an exceptional case, yet in many instances, herds are so badly affected that anything like

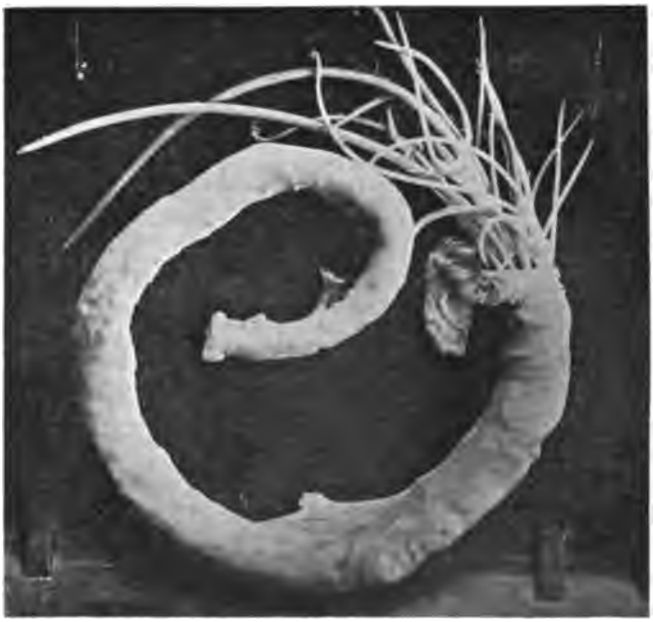


FIG. 12.—Intestinal Worms of the Hog.

profitable gains are absolutely impossible. The writer has seen several cases of this trouble on farms in the State, and it seemed to puzzle the owners that their hogs were not making proper gains. Quite often when pigs are unthrifty an examination will reveal the presence of intestinal worms, the hog louse, or both.

After an animal once gets into the condition as illustrated above, curative measures are usually of little or no value. The sooner such animals are disposed of, the better for the remainder of the herd, and the welfare of the owner. Feed given to a hog in this condition is largely wasted. It would be far more profitable to use the money from the sales of the feed in cleaning and disinfecting the premises. As a preventative for worms, one of the common remedies is turpentine in the daily ration, or given as a drench either with raw linseed oil or milk. The most practical method, however, is to give it in the feed.

In feeding cotton-seed meal experimentally at the Station farm, it was quite noticeable that the hogs used in the experiment were remarkably free from parasites. These hogs were fed regularly on a mixture of turpentine, wood ashes, charcoal, salt, sulphur and copperas.

Intestinal worms gain access to the animal through the feed. Stagnant pools of water and low wet places which are favorable for the development of the worms should not be permitted. The ponds should be drained and low wet places filled in so that standing water will not remain for any length of time. Muddy feeding yards and filthy feeding floors should be avoided. A rotation of pasture crops is very beneficial.

When turpentine is used, it should be given once per day for three or four days, and should be taken at the rate of one teaspoonful for every hundred pounds live weight. The hogs should fast for ten to twelve hours before giving the dose.

Strong, thrifty hogs are not as subject to intestinal worms as are animals improperly cared for. Rational feeding, clean lots, good pastures, pure drinking water, fresh air and exercise are the best preventatives.

CASTRATION.

The castration of the hog is a comparatively simple operation, and may be done by the farmer himself, provided the hogs are not severely ruptured. In simple castration, the principal precautions to observe are to do the work on a warm, sunshiny day, disinfect the instruments and parts well, work quickly, make the incision low so as to admit of free drainage, scrape the cord until it is severed instead of cutting, and keep the pigs from filthy wallow places. As a general thing, after the pigs have gotten well under way, the earlier the work is performed the better, as small pigs notice the operation less, and the chances of rupture are not so great. When pigs are allowed to remain entire until they become excited by the females, they do not make the best use of their feed thereafter. They constantly harass the females in the herd, and in extreme cases the meat becomes tainted after service. This is ordinarily true with stags, but in neglected cases of castrating market hogs, the butchers sometimes discriminate severely against them. The best time to castrate is when the pigs are four to six weeks of age. The operation should not be performed just at weaning time, however. If the operation is delayed until this time it is better to postpone the work until the pigs are eating heartily, as the separation from the mother and the inconvenience resulting from castration may in some cases cause a serious setback.

THUMPS.

The disease known as thumps is caused by feeding excessively on very fattening feeds without proper exercise, which brings on digestive disorders. It is a common practice with many farmers to keep the pigs confined in small lots where sufficient exercise can not be taken to insure a vigorous circulation of the blood which is necessary to promote rapid elimination of the waste products of the body. A heavy ration of corn and close confinement frequently leads to this trouble. If the pigs become too fat, they should be turned into a larger lot and the amount of feed decreased. Some breeders follow the practice of scattering the dry feed, such as corn, in the straw which necessitates the pigs rustling for the corn which falls to the bottom of the feeding floor. A much better plan, however, would be to provide a larger lot for exercise, and feed only enough to keep the pigs growing vigorously. This will in the majority of cases prevent this trouble which might prove serious if close confinement and high feeding are practiced.

Spasm of the diaphram and a short, jerking respiration, which causes an uncertainty in the movements of the pig are the common symptoms. A high condition generally prevails, however, before these symptoms occur, and when they are first noticed, the feed should be gradually decreased and the amount of exericse increased. This disease is common among pigs, the conditions generally surrounding them causing the trouble. If care is exercised in making the surroundings healthy and the pigs are kept growing, the trouble will rarely occur.

RICKETS.

Rickets, a disease which more commonly occurs in the corn belt is caused by feeding largely on a ration containing an insufficient supply of mineral matter. Corn being one of these, explains the reason for the prevalence of this disease in the corn growing states. The bones of an animal are composed largely of mineral matter, and if it is not supplied in the ration, the bones fail to attain that rigidity which is necessary to support the weight of the body. In young animals the bones are somewhat cartilagenous, and if they are not reinforced with mineral matter as the weight of the animal increases, trouble will arise.

The disease comes on rather early in the life of the pig, and to remedy the trouble the ration should be corrected. This can be done by adding wheat middlings, ground soja beans, tankage, skim-milk, or any other feed containing relatively large quantities of mineral matter and protein, provided they are adapted to the use of the pig. Grazing crops will prove very beneficial in overcoming the trouble. It should be the aim always, however, to prevent the trouble rather than effect a cure after the disease is contracted. If pigs are properly supplied with ash and protein from the beginning, and are fed moderately, thumps or rickets will seldom, if ever, give trouble to the swine farmer.

SCOURS AND CONSTIPATION.

If pigs begin to scour their condition should be looked after closely, as the trouble will cause a severe setback if they are not handled properly. In a majority of cases the trouble originates in the mother from feeding highly carbonaceous feeds, making sudden changes in the diet, or giving feeds in a badly fermented condition.

In all cases of scours, the cause should be removed, and the mother fed on appetizing feeds. The feeding troughs should be kept clean, and the pigs allowed the run of a clean, sunny pasture. Lime water given in the feed of the sow will in many cases be of material aid in removing the trouble. If the houses and lots are kept in a clean sanitary condition, and the feed is looked after closely, and sufficient exercise given, there is not likely to be much trouble from scours.

Constipation is generally brought on by careless feeding and lack of proper exercise. The trouble is common among brood sows, and often gives rise to great loss at farrowing time from trouble in giving birth to the pigs, which may result in a large number of them coming dead.

Laxative feeds should be given to overcome the trouble. Linseed meal is excellent for brood sows, but it should be used with judgment as overfeeding may cause a derangement in the opposite direction. If pastures and root crops are provided in abundance, and plenty of exercise given, it is not likely that serious trouble will be experienced. In cases of excessive constipation, epsom salts in three to four ounce doses given in the feed will usually overcome the trouble to such an extent that the case may be handled successfully by proper regulation of the diet.

RHEUMATISM.

Rheumatism is commonly caused by allowing hogs to sleep in damp, filthy and improperly ventilated quarters. The system of ventilation should be such that there will be no direct currents of air striking the animals. The sun should have free access to the houses at all times. This will keep the sleeping quarters in a dry, sanitary condition.

When affected with rheumatism, the animals generally become unthrifty, and fail to make proper use of their feed, the appetite becomes dull which gives rise to the rough, staring coat. Prevention should be the first aim of the owner, and to accomplish this, the yards, pastures and houses should be made dry and clean. Damp bedding and cold floors should be avoided. If the hog house has a cement floor, false wooden floors should be provided, especially in the sleeping apartment of the building.

Other treatment is of little avail if comfortable sanitary quarters are not provided.

PRACTICAL DEDUCTIONS ON SWINE MANAGEMENT.

Keep the hogs healthy at all times. The market hog is only retained for a comparatively short time, six to eight months. If this period can be passed safely, the profits are insured. If disease has been allowed to fasten itself upon the herd, it may loosen its grip with a comparatively small loss to the owner, or it may take practically the entire herd before the farmer locates the trouble. If the following twelve rules are observed, much loss will be saved:

> Keep only healthy, strong boned, vigorous feeders and breeders.
>
> Provide plenty of pure water, sunshine, range and green forage crops.
>
> Do not allow newly acquired animals to mix with the herd. Keep them in separate quarters for three to four weeks.
>
> Feed with judgment, be regular and watch for any unusual symptoms in the herd. See that every hog responds at feeding time. Do not overfeed or use fattening feeds excessively.
>
> Allow the breeding stock plenty of exercise, and keep in a medium fat condition. Do not have them excessively fat at any time.
>
> Feed plenty of ashes, charcoal, sulphur, lime, turpentine and copperas. These are excellent preventatives for intestinal worms, a common source of trouble.
>
> Do not allow visitors around the herd after coming from a farm where cholera or other contagious diseases are known to exist.
>
> See that the hogs are kept free from lice and intestinal parasites. Avoid filthy wallows and foul drinking water. Intestinal worms are likely to be contracted from such places.
>
> Do not feed for excessive weight. Market the hogs when they weigh from two hundred to two hundred and fifty pounds. Greater weight is made at a heavy cost for feed consumed and

> the risk is great, disease often attacking the herd during this prolonged period of feeding.
>
> Clean the houses, lots and pens often, and disinfect freely. Let in the sun to do its portion of the work. Sunshine is the most powerful disinfectant known. Germs of disease can not live in its presence.
>
> Keep the hogs separated in droves of twenty to twenty-five. When allowed to run in larger numbers, the risk is often much greater. This applies especially to fattening hogs, as conditions make it necessary to segregate breeding males and females.
>
> Do not make it a practice to serve the herd boar to outside females. Disease is sometimes contracted from such sources.

These rules cover in a general way what is considered proper management for a herd of hogs. Many minor details must be considered in practice, yet if the above rules are carefully observed a great amount of trouble will be avoided. Good judgment in feeding and proper management will usually avert trouble. The feeder should keep a watchful eye for any stragglers. If the feed trough is not approached when feeding time draws near, there is trouble brewing somewhere. Try to locate the trouble at once. If contagion is suspected, transfer the well hogs to new quarters immediately.

CERTIFIED SWINE BREEDERS' ASSOCIATIONS.

Name of Breed.	Book of Record.	By Whom Published.
Berkshire	American Berkshire Record.	American Berkshire Association, F. S. Springer, Secretary 510 E. Monroe St., Springfield, Ill.
Poland China	American Poland China Record.	American Poland China Record Association, W. M. McFadden, Secretary, Union Stock Yards, Chicago, Ill.
Do	National Poland China Record.	National Poland China Record Co., A. M. Brown, Secretary, Drawer 16, Winchester, Ind.
Do	Standard Poland-China Record.	Standard Poland-China Record Association, Geo. F. Woodworth, Secretary. Maryville, Mo.
Do	Southwestern Poland-China Record.	Southwestern Poland-China Record Association, H. P. Wilson, Secretary, Gadsden, Tenn.
Duroc-Jersey	American Duroc-Jersey Record.	American Duroc-Jersey Swine Breeders' Association, T. B. Pearson, Secretary, Thorntown, Ind.
Do	National Duroc-Jersey Record.	National Duroc-Jersey Record Association, H. C. Sheldon, Secretary, Peoria, Ill.
Chester, Ohio Imp.	Ohio Improved Chester Record.	Ohio Improved Chester Swine Breeders' Association, J. C. Hiles, Secretary, Cleveland, Ohio.
Tamworth	American Tamworth Swine Record.	American Tamworth Swine Record Association, E. N. Ball, Secretary, Ann Arbor, Mich.
Yorkshire	American Yorkshire Record.	American Yorkshire Club, Harry G. Crum, Secretary, Whitebear Lake, Minn.
Hampshire	American Hampshire Swine Record	American Hampshire Swine Record Association, E. C. Stone, Secretary, Armstrong, Ill.
Cheshire	Cheshire Herdbook	Cheshire Swine Breeders' Association, Ed. S. Hill, Secretary, Freeville, N. Y.

INDEX

PAGE

Appetites, depraved ... 173
Ash, necessity of ... 160
Association, certified swine breeders ... 183
Bedding ... 156
Boar, selection of (*illustrated*) ... 137
Breed, selection of ... 136
Breeders' associations, certified ... 183
Breeding—
  condition of sows ... 144
  crate (*illustrated*) ... 155
  young animals (*illustrated*) ... 143
Canada field peas and oats (*illustrated*) ... 162
Castration ... 178
Condition of swine industry ... 134
Constipation ... 180
Constructing the A-shaped hog house (*illustrated*) ... 153
Contagious diseases ... 174
Corn, value of ... 165
Cost of producing pork ... 170
Dairy by-products ... 165
Deductions on swine management ... 181
Dipping tank (*illustrated*) ... 174, 175
Diseases, contagious ... 174
Early maturity ... 168
Farrowing—
  care of pigs ... 145
  care of sow (*illustrated*) ... 145
Fattening for market ... 167
Feeding—
  hogs ... 142
  methods of ... 169
  objects of ... 169
Feeds—
  combination of ... 157
  preparation of ... 160
  selection of ... 158
Fencing ... 154
Forage crops, succession of (*table*) ... 161-164
Gestation period ... 151
Health ... 171
Heat, time of ... 151
Hog—
  instincts of ... 135
  louse ... 174
  lousy (*illustrated*) ... 150
  white ... 140

PAGE
House, type of (*illustrated*) 151, 152-154
Inferior feeding hogs (*illustrated*) 135
Instincts of hog 135
Intestinal parasites (*illustrated*) 177
Kitchen wastes 167
Litters—
  number of 148
  size of 149
Louse, the hog 174
Management of hogs 142
Market, age to fatten for 167
Maturity, early 168
Milking capacity of sows 146
Parasites, intestinal (*illustrated*) 177
Pastures (*illustrated*) 154-162
Pigs—
  at farrowing, care of 145
  weaning of 149
Protein, necessity of 160
Pork, cost of producing 170
Registration 141
Rheumatism 181
Rickets 179
Sanitation 171
Scours 180
Selection of—
  breed 136
  boar (*illustrated*) 137
  sow 139
Sow—
  at farrowing, care of (*illustrated*) 145-172
  for breeding, condition of 144
  milking capacity of 146
  selection of 139
State, adaptability for swine growing 133
Summary 132
Sunshine, value of 150
Swine—
  growing, adaptability of State 133
  industry, condition of 134
  management, deductions on 181
Thumps 179
Usefulness, period of 147
Weaning of pigs 149
White hog 140
Young animals, age to breed (*illustrated*) 143

BULLETIN 208 JUNE, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

FIG CULTURE IN NORTH CAROLINA

Edwards & Broughton Printing Co.
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. R. COOPER	Wilmington	M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Assistant Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

FIG CULTURE IN NORTH CAROLINA.

By F. C. Reimer, Horticulturist.

The Station is constantly receiving inquiries regarding fig culture in this State, and requests for literature on the subject. Judging from the large number and the nature of the inquiries, there seems to be considerable interest in the subject. Most of these inquiries pertain to the culture of this fruit; but a great many are in reference to the cause and remedy of the dropping of the immature or green figs. As the Station has heretofore never published a complete bulletin on the subject, it has been unable to supply the demand for such literature.

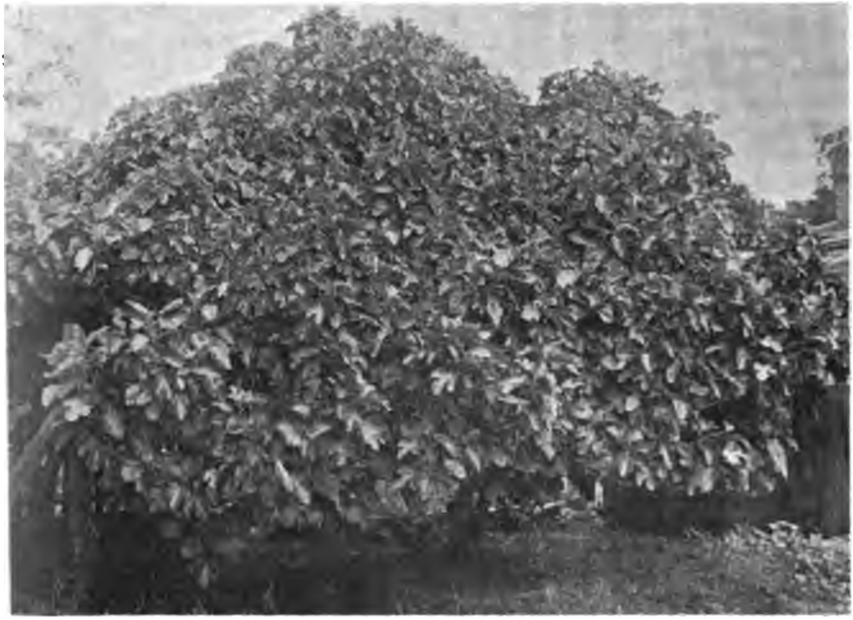


Fig. 1.—Excellent Fig Tree.

The writer feels that a publication of this kind is needed. He is convinced that the fig should be more widely grown, especially in the eastern half of the State. He knows of fig trees in most of the eastern counties, growing luxuriantly and bearing good crops even under the greatest neglect. The fig is one of the finest fruits for home use grown in the South. It is delicious and wholesome when eaten fresh and fig preserves are the standard of excellence. The home fruit orchard is almost a thing of the past on many North Carolina farms, due to the large number of new insects and diseases which have been brought in during the past twenty-five years. Fortunately, the fig is not seriously affected by these troubles, and can be grown without the constant use of the spray pump.

Furthermore, the fig is one of the most profitable fruits grown in the Upper South. Fig culture is really in its infancy; and very few people realize the possibilities of the industry. Even most of those who have grown this fruit for home use do not know that by selecting the proper varieties and by using proper methods figs can be shipped to the large distant markets. The writer knows of one acre of figs at Raleigh, North Carolina, which has during the past five years probably netted the owner greater returns than any acre in other fruits in the eastern half of the State.

SUITABLE LOCALITIES.

Eastern North Carolina is favorably situated for the growing of figs for market. It is practically the northern limit of commercial fig culture in the Eastern States. This gives the grower a distinct advantage over the grower farther south, as he is nearer the large Northern markets. The fruit is very perishable and can not be shipped long distances, unless picked when in a very immature condition. To pick it long before it has properly ripened means a fig of very poor quality, as this fruit develops high quality only when allowed to ripen on the tree. The fruit grown in this State need not be picked for shipment until practically ripe. The express rates are also considerably less on fruit shipped to the North from this State than from sections farther south.

CLIMATIC REQUIREMENTS.

The climate of the eastern half of this State is well suited to the growing of figs; and in this respect this section has a distinct advantage over the Lower South. Strange as it may seem the fig tree is often more severely injured by cold weather in the Lower South than in this State. This is due principally to the marked changes in weather during the winter in that section; as, long warm periods suddenly followed by cold weather. The fig is very sensitive and starts into growth quickly during such warm spells, and then is readily injured by cold weather. As long as the trees of our hardy varieties of figs remain dormant, they are seldom injured by cold. It is very rarely that we have enough warm weather during winter in this State to start our leading varieties into growth, and it is therefore seldom that they are severely injured by cold.

The climate of this State during summer is also well suited to the fig. For best results the first half of the summer should be relatively moist with a heavy rainfall, so as to produce long, vigorous branches, which are necessary for a large crop of fruit. The last of the summer and early fall, while the fruit is ripening, should be dry with a great deal of sunshine to prevent the souring of the fruit and to develop sugar and flavor. The climate here corresponds very well with these requirements. While considerable rain falls during August, this usually comes in a few heavy showers, and the month is characterized mostly by hot, bright, sunny weather. The bulk of our figs for market are harvested during September, while the weather is very dry, with intense sunshine—the ideal conditions for the maturing of figs.

The fig can be grown in any section of the State east of the mountains, but usually needs some protection in the Upper Piedmont; and it should never be grown there except for home use. The Coastal Region and the Lower Piedmont are well adapted to this fruit. The most favored sections are found in the extreme eastern part of the State, along the coast. There the winters are mild, with so little variation that very old fig trees have never been seriously injured by cold. In the Piedmont section excellent trees are found as far west as Caswell and Rowan counties, but these are of the hardiest varieties and are well protected from severe cold winds. The western limit of commercial fig culture in this State can not be definitely designated, as much depends on local conditions and the variety planted. An elevation above sea-level of one hundred feet in the northern part of the State, four hundred feet in the central part, and five hundred feet in the southern part roughly indicates this limit.

SOIL.

The fig can be successfully grown on a greater variety of soils than most other fruits. It is grown on all soils, ranging from the light sandy soils along the coast to the heavy, tenacious red clay soils of the Piedmont section; and from the low, moist, marshy soils in the coastal region to the high, dry soils of the sand hill region. But this does not mean that it does equally well on all soils.

The best soil for the figs generally grown in this State is a well-drained, moist, mellow, sandy loam well filled with humus. It should contain an abundance of lime, especially if the figs are to be shipped long distances, and where the best quality is desired. The basis for such soils is found in many places in the coastal section, where the soil contains large deposits of sea shells and considerable marl. By good drainage and the addition of humus these soils can be made almost ideal for figs. In fact most of the soils in this section will answer very well if an abundance of humus is incorporated, to conserve moisture during long dry seasons.

The heavy clay soils of the Piedmont section will not produce a fig of the highest quality no matter what treatment is given. Such soils produce a coarse fig deficient in sugar and in shipping qualities. Still such soils, when thoroughly drained and loosened up with large quantities of vegetable matter, can be made to produce very satisfactory crops of figs. Then too, these clay soils have a distinct advantage in that the nematode worm does not attack the fig seriously on such heavy soils.

PROPAGATION.

The fig is easily propagated by cuttings, layering, ring-budding, and grafting. In this State, propagation by cuttings is the easiest and most satisfactory way. The work can be done at almost any time of the year; but by far the best results are obtained if done during the winter while the plant is dormant.

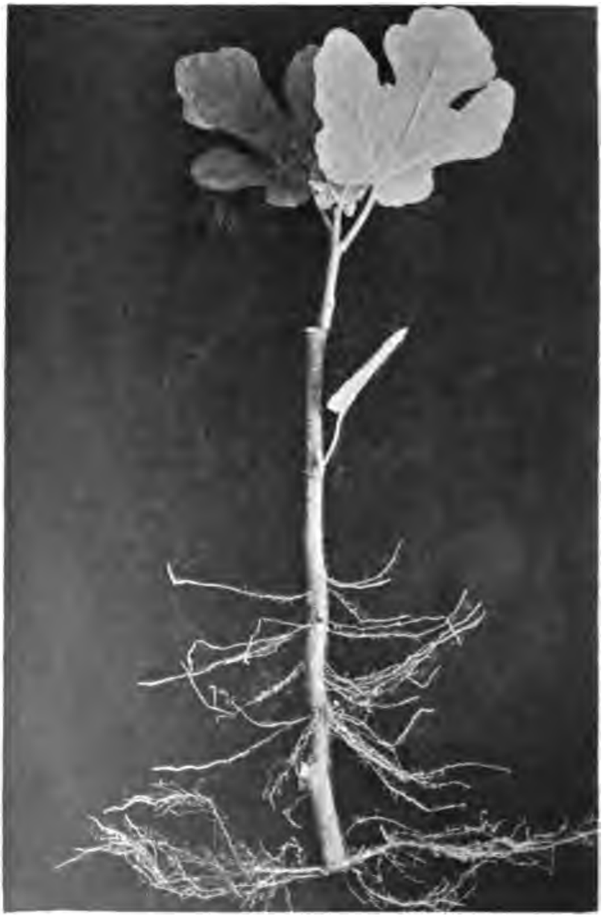


FIG. 2.—Well Rooted Fig Cutting.

The cuttings should be taken from strong, healthy plants of the desired variety and preferably from plants growing in the immediate locality. Select the one-year-old branches that are plump and stocky, which are usually found on the outside, where they were well exposed to the light. Do not take the long, slender shoots or suckers found on the base of the plant.

A good cutting should be at least one foot long, or preferably longer. The cut ends should not expose any pith, but the hard wood of the partition found at the node. The cuttings should not be allowed to dry out, or become shrivelled; as soon as made they should be tied into bundles of convenient size and buried in moist sand. The following spring they should be planted either in the field where they are to remain permanently or in the nursery row. The latter method is usually preferable, as they can be given better care and grown at less expense. They should be planted deep, leaving only the uppermost bud just above the surface of the soil. Some prefer to make the cuttings late in the spring and plant them at once in the field. This is certainly the most economical method.

PLANTING.

The soil should be thoroughly prepared by deep ploughing and enough disking and harrowing to pulverize every clod. Usually clay soils are not ploughed deep enough, especially by the beginner. It must be remembered that the fig is naturally a very shallow-rooted plant, especially where the subsoil is hard and comes up near the surface. Clay soil should be ploughed eight to ten inches deep and then subsoiled to a depth of six to eight inches. This gives opportunity for proper root development, and storage of large quantities of water.

The best time to do the planting is in the spring. Fall planting is not advisable, as the young plant can not endure very much cold until it becomes well established. If the planting is done in the fall or winter the young plant should be entirely covered with dirt until spring.

The distance apart to plant will depend on the variety and the method of training, whether in tree or bush form. Such semi-dwarf varieties as Brown Turkey are usually planted 10 x 10 or 12 x 12 feet apart in this State. Large growing varieties, like Celestial, need more room—15 x 15 to 20 x 20 feet.

For best results the fig should be planted deep. The young plant should be planted from four to six inches deeper than it stood in the nursery row; and then the entire top of the plant should be cut off at the surface of the ground. This induces a number of branches to come out from below the ground, which give the clump or bush form so desirable in the Upper South. If the cuttings are planted in the permanent places in the field the plants should be cut down to the ground one year after planting. Some growers put from three to five plants or cuttings at each place instead of one, with excellent results.

CULTIVATION AND MULCHING.

One of the most important questions connected with fig culture is that regarding the best method of cultivation. Some advocate no cultivation, contending that it does more harm than good, while others recommend the most thorough kind of cultivation. While good results are obtained from both methods, by far the best results are obtained where the ground is kept mellow, moist, free from weeds, and is cultivated shallow so as not to disturb any roots. The best way to do this is to keep a heavy mulch of compost on the ground under the trees at all times, and to keep the weeds down with a hoe or shallow working cultivator. One of the best fig growers in the State is constantly accumulating compost by putting manure, straw, paper, and all sorts of refuse in a pile and allowing it to rot partly before using. Fig. 3 shows the ideal condition under one of his fig trees. The soil under this mulch is in perfect condition for figs at all times. It never bakes or dries out during summer; and never freezes during winter, which is a very important matter in preventing injury from cold.

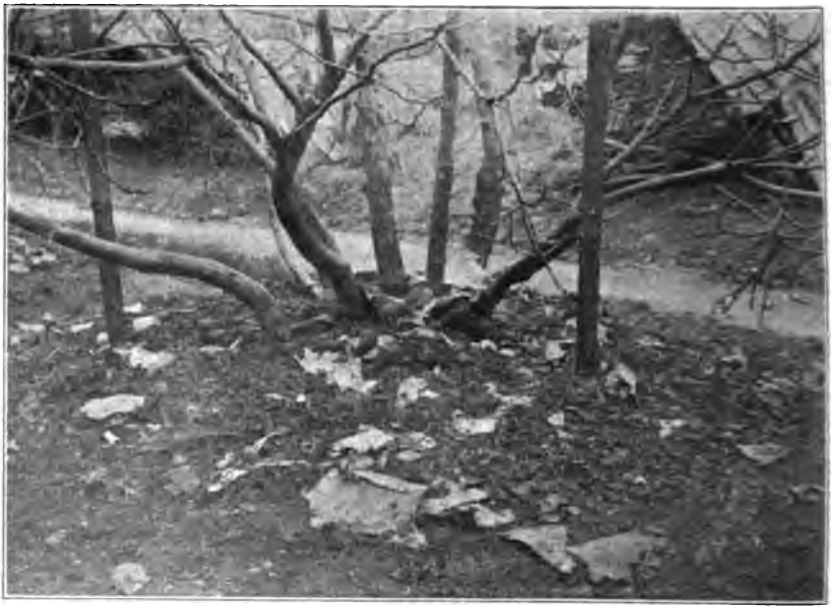


FIG. 3.—Mulch of Compost; Showing Ideal Condition Under a Fig Tree.

MANURE AND FERTILIZERS.

The fig is a gross feeder. There is probably no other fruit tree that can use to advantage such large quantities of plant food. The growth of the plant and the quantity of fruit produced are in direct proportion to the quantity of plant food supplied. One of the most important things in this State is stable manure, as our soils are so deficient in humus and nitrogen. The manure supplies the humus in the best form. This loosens the soil and enables it to store large quantities of moisture, which is essential in growing figs. Another important constituent is lime. Some of our soils are so deficient in lime that they are actually acid, which means that large quantities must be supplied if good crops are desired. From one-half to a ton per acre applied broadcast around the plants will give good results.

The fig also uses large quantities of potash and phosphorous acid. On our clay soils very little potash need be supplied if large quantities of stable manure are used, but on most of the sandy soils it must be supplied. Phosphoric acid can be advantageously applied in the form of ground phosphate rock. This should be put on the compost around the plant, or first mixed with the manure in the stable or on the compost heap. Of course the amount of commercial fertilizer to apply will depend entirely on the fertility and condition of the land, and the intensiveness of the cultural methods. If the trees are suffering from a lack of nitrogen it will usually be indicated by yellowish leaves and stunted growth. An application of 200 pounds of nitrate of soda or 400 pounds of cotton seed meal, per acre, will usually correct the trouble.

IRRIGATION.

The fig bears its fruit in the axils of the leaves; usually one in each axil. The longer the branches, the larger will be the number of leaves, and hence the larger the crop of fruit produced. The crop of fruit then is in direct proportion to the vigor of the plant. To produce a vigorous growth this plant must have large amounts of water. It has often been observed that a fig tree growing near a house where the roots can extend into the moist soil under the house, is usually much more vigorous than one growing in the open ground. Soils which are well supplied with humus, which acts as a great sponge in storing up water, give far better results than soils deficient in humus. Some of the finest crops of figs are grown on bottom land where the soil never becomes very dry.

This State has an annual rainfall of over fifty inches, which if properly conserved is sufficient to grow a good crop of figs. Many of our soils are in such bad mechanical condition, however, that most of this rainfall is lost. On such soils, and during very dry seasons on good soils, irrigation becomes necessary for best results. This is usually necessary during September and October, when the bulk of the fruit is ripening and at which time comparatively little rain falls. The most economical method of irrigation is where the water can be obtained from some nearby stream or brook. But where this can not be done a pumping plant with a large storage tank is necessary. A good windmill or gasoline engine is excellent for this purpose. A leading grower at Raleigh, North Carolina, gets his water from the regular city water supply. He has several hydrants per acre, to which he attaches a long rubber hose so that the water can be carried to every plant. He has used as much as 200,000 gallons a season on one acre, mostly during August and September. His main object is to keep the plants growing and to produce fruit of large size. A heavy mulch should be kept around each plant to get the best results from irrigation.

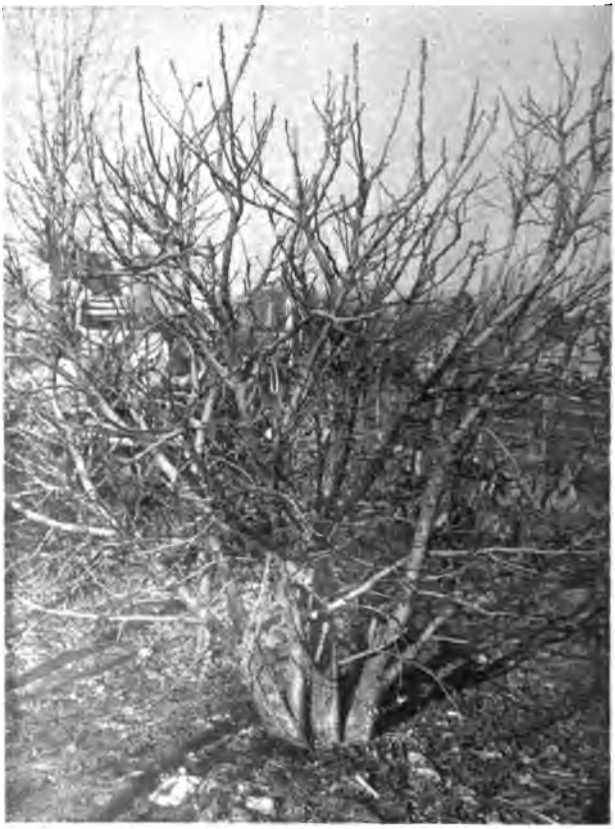


FIG. 4.—Well Branched Fig Tree, Showing Best Form for the Upper South.

PRUNING AND TRAINING.

The subject of pruning and training figs has received altogether too little attention in the past. While growers in some sections, especially in the Lower South, have little faith in this operation, it is an absolute necessity for best results in the Upper South. This applies especially to the matter of training. In this State the fig should never be grown as a tree; that is, with a single trunk. Every effort should be made to induce it to form a bush or stool. The advantages of this are many: it offers better opportunity for protection against cold; the trees come into bearing earlier should they be frozen back to the ground; they bear more fruit during the first five years; and the fruit is more readily gathered.

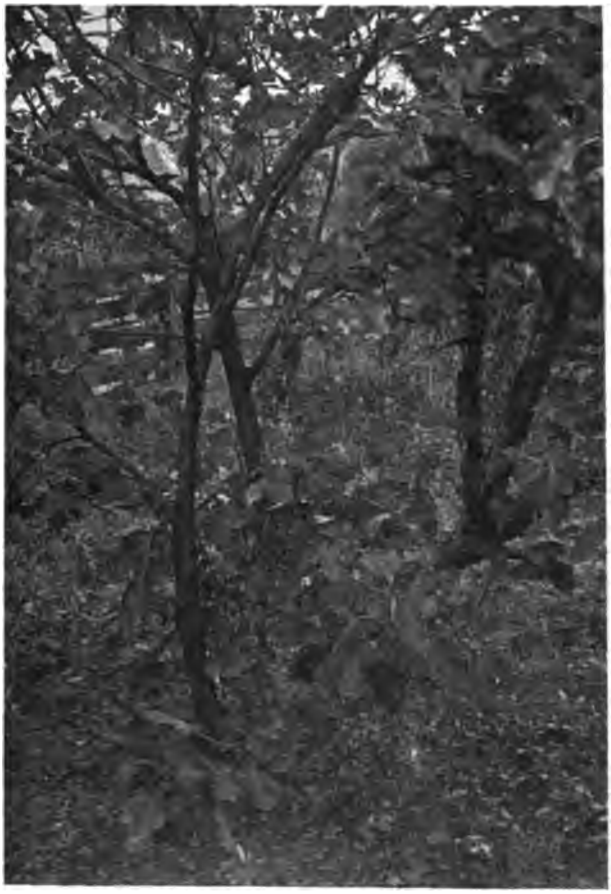


FIG. 5.—Fig Tree Showing the Worthless Sprouts on the Body Which Should be Removed.

As soon as the young plant has been planted it should be cut back to the ground; if cuttings are planted cut them back a year later. If the plant continues to send up only a single stem it should be repeatedly cut back until it throws up the desired number of shoots. If too many shoots come up cut off all but five or six of the best. If these grow vigorously and become too tall and slender they should be pinched back during the first summer or cut back the following winter. Every effort should be made to induce low branching, as shown in Fig. 4.

As soon as the desired shape has been attained and the plant begins bearing, very little pruning should be done. There is little to be gained and much to be lost by pruning a bearing tree of the varieties usually grown here. The principal thing is to cut out entirely all water sprouts, which are long, slender, weak shoots springing from the body of the tree. These should be removed as soon as they appear, and it will be necessary to go over the trees several times each summer. Of course all dead wood should be removed. Wherever the head of the tree becomes too thick, thinning out should be practiced. In all cases where a branch is cut off it should be removed entirely, cutting it off at the base so as to leave no sign of a stub.

WINTER PROTECTION.

In the extreme eastern part of this State no protection is needed during winter, except to locate so as to avoid severe cold winds. No other protection is usually needed in the Lower Piedmont; but it is a necessity during very cold winters, especially while the plant is young. Cold weather like that experienced during the winter of 1899 freezes the plants down to the ground unless thoroughly protected.

There is nothing that injures a fig tree more quickly than cold. severe winds during winter. A fig tree can endure considerably more cold where sheltered than where exposed to strong, dry, cold winds. The first means of protection then is to locate the fig orchard so as to have a group of buildings, a forest, a hill, a high fence, or a high thick evergreen hedge on the north and west sides. If no such place is available, then plant a hedge of California privet along the north and west side of the field; or construct a high board fence.

The second most important matter is to keep a heavy mulch under the trees to prevent freezing of the soil and to keep it moist. This protects the very shallow roots from freezing and supplies moisture to the top, a very important matter in preventing injury from cold.

Until the plants are five years old, the best method of protection is to cover them with dirt. To do this most effectively, the plants are trained to grow in an inclined position, as shown in Fig. 6. During

November they are bent to the ground and covered with dirt. An excellent method to prevent rotting of the branches during warm weather in winter is to cover them with a large divided banana crate, or similar covering, before putting on the dirt. See Fig. 7.

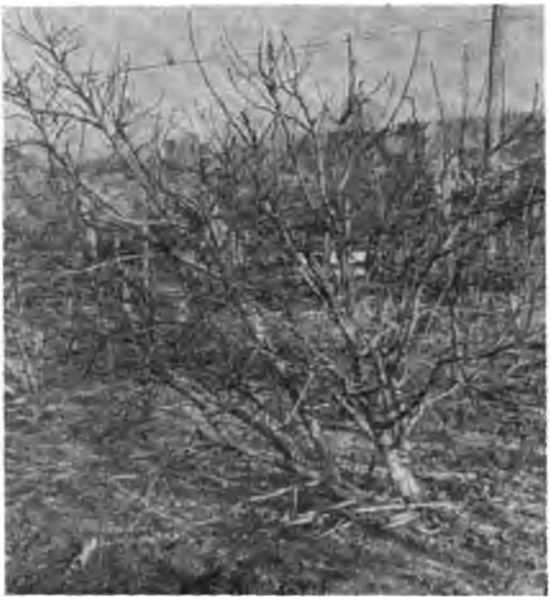


FIG. 6.—Excellent Method of Training Tree to Facilitate Bending Down and Covering During Winter.

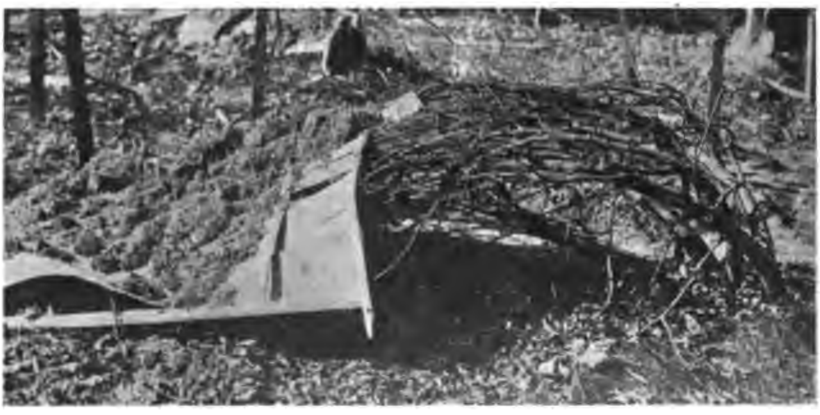


FIG. 7.—Fig Tree Bent Down and Covered with Banana Crate and Dirt, to Protect From Cold.

After the plants are too large to be bent to the ground the best method is to put a small rope around the bush, draw the branches together, then bend the whole plant over, stake and cover it, as shown in Fig. 8. For covering, various materials are used, as, boards, slabs, banana crates, canvas, straw, weeds, excelsior, and pine branches. The main object is to exclude the sunlight to prevent the buds from swelling, and to protect the plant from cold winds.

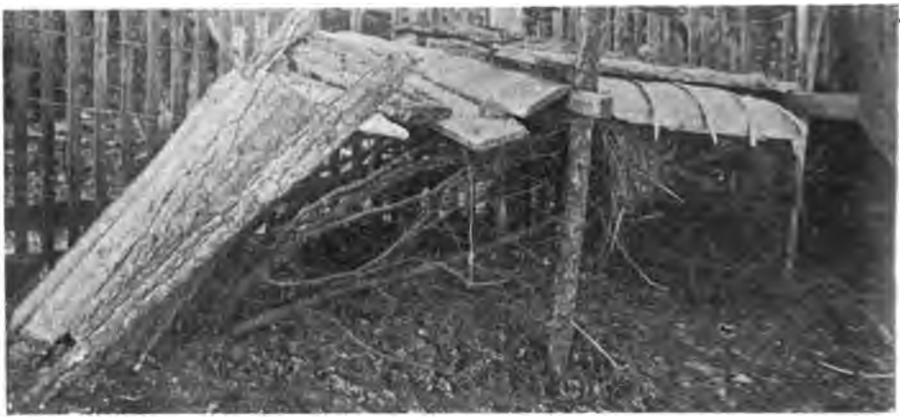


FIG. 8.—Tree Bent Over, Staked and Covered With Slabs to Exclude Sunlight During Winter.

HARVESTING.

The varieties most generally grown in this State produce two crops—one ripening principally during June, known as the "breba" crop, and the other during August, September, and October. The first crop while not ripening very much earlier than the second crop is very distinct from it, as the fruit of this crop is borne on the last wood produced the previous season. The second crop is borne on the new wood of the season. The first crop is small, but the individual figs are very large. The second crop is very large and the individual fruits are medium to large in size.

The trees should be gone over every day during warm weather and all figs that are ripe should be picked. If the fruit is for home use or the local market, it should be allowed to become fully ripe on the tree. The figs will then be soft and of the highest quality. If they are to be shipped to distant markets, they should be picked about two days earlier. If to be used for preserves, they should be picked when fully ripe but before cracking open.

The weather during the picking season should be dry with an abundance of sunshine. If it is rainy and cloudy the figs crack open, are of poor quality, and soon sour on the plant. If there is a heavy dew on the plant in the morning the figs should not be picked until the plants are dry. If a single fig in a box is wet when packed it will often destroy the entire lot within twenty-four hours.

The fruit must be carefully picked by hand and the work done by the best labor obtainable. Every effort should be made in pulling the fruit to have the stem remain on the fig. If it does not it breaks the skin at the base of the fruit, and decay sets in immediately. As the fruit is picked prematurely for market, the stem parts from the branch with difficulty. The most satisfactory way to pick is to clasp the stem instead of the body of the fig, so as to prevent breaking the fruit at the base. This means sore thumbs and fingers, which can be prevented by wearing thin gloves. Another method is to cut the figs off with a small, sharp knife; but unless considerable care is exercised the leaf subtending the fig is also cut off.

In gathering the fruit, never use deep receptacles, as the fruit is certain to be mashed by its own weight. One of the best receptacles for this purpose is the carrier used by strawberry pickers. As soon as picked the figs should be taken to the packing shed without delay.

The fruit of most varieties grown in this State can easily be picked without the aid of ladders. With the larger growing kinds, like the Celestial, a step-ladder is sufficient for this work.

MARKETING.

The fig is one of the most difficult of all fruits to market. The work demands a thorough knowledge of the characteristics of the varieties grown, great care in picking and considerable skill in packing. This applies especially to figs sent to distant markets.

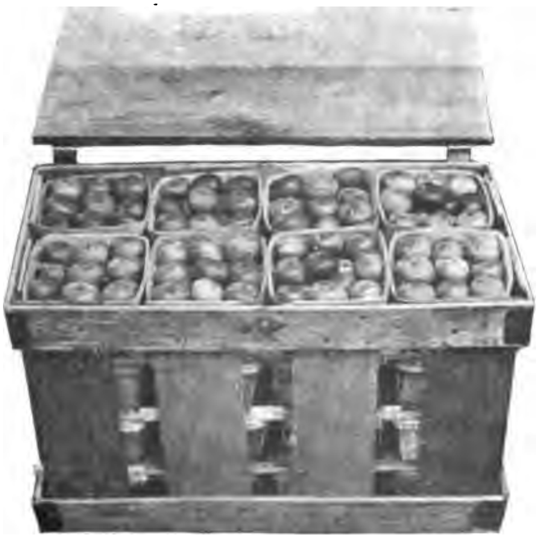


FIG. 9.—Crate of Brown Turkey Figs, Showing Proper Method of Packing

By far the best package to ship the fruit in is the regular 24-quart or 32-quart strawberry crate. The six-basket peach carrier has been used, but the baskets are so large that the fruit often mashes badly when shipped long distances.

The fruit should fit snugly into the quart boxes or it is certain to get bruised. It requires twenty-two large figs of our leading variety to fill a quart. These should be placed or packed in the quart box in the following manner: Place nine of the figs on the bottom with stems pointing up. The next layer consists of four figs with stems pointing down; these fit down into the four large spaces around the central fig on the bottom. The top layer consists of nine figs with stems pointing downward. See Fig. 9.

With the smaller fruits no systematic method of packing can be followed. The fruit is simply placed in the quart baskets in the same way as strawberries, with the upper layer arranged in a neat, attractive manner.

The fruit must be perfect. Not a single specimen that is soft, broken, or that shows any signs of decay, should go into the package The fruit should be perfectly dry or mould and rot will certainly result.

The fruit should be shipped by express; or in refrigerator cars where large quantities are marketed. Never should they be sent by freight except under refrigeration.

As very few fresh figs are shipped to the large cities, there is practically no competition at the present time. This makes the industry a very profitable one. The prices on the Northern markets usually range from ten to thirty-five cents per quart. When planted 15 x 15 feet apart an acre will contain one hundred and ninety-three fig bushes. When well established every bush should produce at least one bushel of fruit. One of the best growers in North Carolina states that his acre of figs has netted him from $300 to $500 a year during the past five years.

The figs which become too ripe for long shipments should be sold on the local market. Many varieties are not at all suited for shipping purposes; these should either be sold on the local markets, preserved or canned.

USES.

The fig is undoubtedly one of the most delicious fruits grown in the South. Furthermore, it is one of the easiest plants to grow, and should be found in every garden.

The fruit is delicious when eaten fresh. This of course does not apply to all varieties, as some are distinctly insipid. But it is true of such varieties as Celestial, Ischia White, and many others. The skin should be removed when eaten fresh to get the exquisite flavors. Still the fruit of the Celestial when left on the tree until it begins to shrivel can be eaten with the skin. With all varieties, the fruit is at its best when left on the tree until it becomes thoroughly soft; this means that the finest fresh figs will never be found on the distant markets.

Fig preserves are regarded by many as the finest of all preserves, and there is always a good demand for them at excellent prices. This State ought to preserve a ton for every pound preserved at the present time. This is the proper way of disposing of fruit that can not be shipped; especially in remote sections of the State.

The fruit is also excellent when canned, pickled, or when made into marmalade, jam and paste.

The varieties grown in the Upper South are not well suited for drying purposes.

VARIETIES.

The most important characteristic of a variety for this State is that it must be hardy enough to endure our cold winters. Very few of the varieties tested so far are hardy enough for this State.

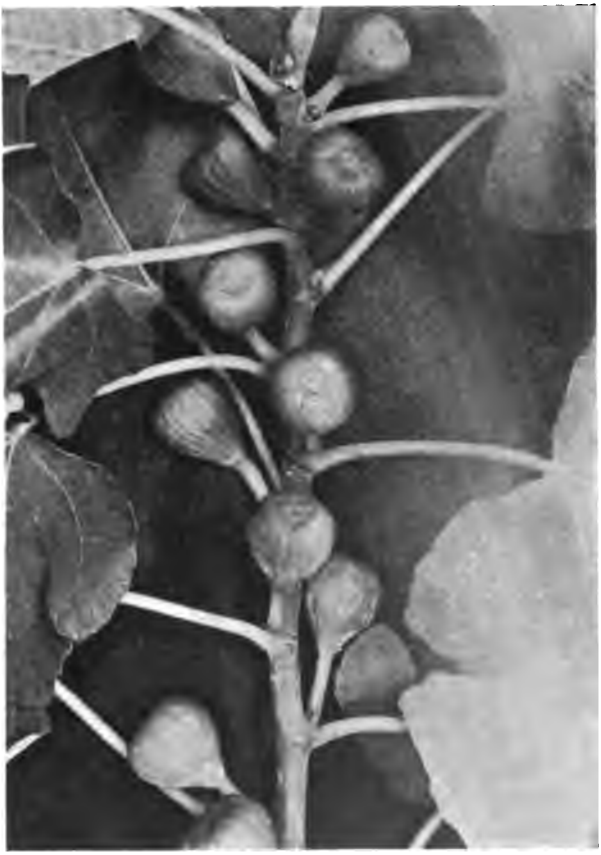


FIG. 10.—Branch of Brown Turkey, Showing Heavy Fruiting Habit. One-third Natural Size.

Another important characteristic is that the tree should be a dwarf or semi-dwarf, so that it can be easily protected by covering if necessary.

The leading variety is *Brown Turkey.* This is a variety with semi-dwarf tree, very hardy, and is a heavy bearer. It bears a small crop of "brebas," and a very large second crop ripening from the latter part of July until October. The fruit of the first crop is very large, while that of the second crop is medium to large in size.

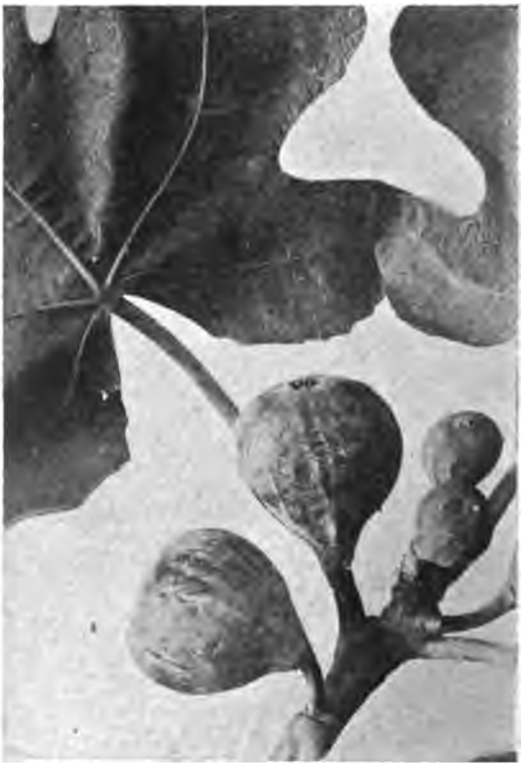


FIG. 11.—Branch of Celestial. Two-thirds Natural Size.

The fruit ranks as fair to good in quality. The fruit stands shipment well; and for this purpose it has no equal among all the other figs grown in the State.

For home use, the best variety is *Celestial.* The tree is a strong, vigorous grower and is very hardy. It soon becomes too large to be covered during the winter, and this vigorous growing habit is an objection to the variety in cold climates. The tree bears only one crop, which is usually designated as the second, or main crop, since the fruit comes on the new wood. The crop is large and ripens during July and August. The fruit is small in size and this is its chief defect; but it makes up in flavor and quality what it lacks in size. It is far better suited for home use and local market than for the general market.

Another variety that has given excellent results and that ought to be more generally planted, is *Ischia White.* It is very productive, and the figs are large and of excellent quality. Unfortunately, it is not so hardy as the Celestial or Brown Turkey.

The Station has tested many varieties of figs during the past, but most of these have proved worthless. The following varieties: Brunswick, Lemon, Ischia Black, San Pedro, and Adriatic White, although commonly found in the State, are not worth the space they occupy.

Among the newer varieties the following are very promising: New French, Peau Dure, and Bourgeassotte Grise. These are being thoroughly tested and we hope to have them tested further in various sections of the State.

The true Smyrna figs are of no value here, and therefore should not be planted except for experimental purposes.

DROPPING OF IMMATURE FIGS.

The Station receives a large number of inquiries every year regarding the dropping of green or immature figs. These come from every section of the State where figs are grown, and often from other States. There are many fig trees in the vicinity of the Station and elsewhere in the State which drop their figs prematurely as regularly as the seasons come.

There are many fig trees in this State which would produce several bushels of fruit every season if it could grow to maturity; but when about two-thirds grown the fruit turns yellowish, begins to shrivel, becomes dry and tough, and then drops. With the first crop it all drops within a few days; while with the second the dropping extends over a long period, each fruit falling as soon as it reaches a certain size or stage of maturity.

Various causes have been assigned for this, such as cold weather, very dry or very wet weather, too rapid growth, poor soil, and lack of proper fertilization. The writer has made a special study of these figs, and has determined the cause in nearly every instance. All persons who had written regarding this trouble were asked to send fruit of these trees to the Station for examination. Many specimens were received from various sections of the State and many others were collected by the writer in this vicinity.

CAUSE OF PREMATURE DROPPING.

In every instance where the dropping was at all serious it was found to be due to the kind of fig grown, and not to the conditions surrounding the plants. At least ninety-five per cent of the figs examined were seedlings of the true Smyrna fig. Most of these seedlings bear fruit very similar to that of the caprifig; very rarely is it like that of the true Smyrna fig. It has long been known that the Smyrna figs, in order to mature their fruit, must be fertilized by pollen from the caprifig. Hence the similarity of many of the Smyrna seedlings to the caprifig. (Fig. 12.)

The caprifig produces two kinds of flowers: the gall flowers which are situated on the sides and bottom of the hollow receptacle, and the male flowers which form a ring around the inside of the eye. The gall flowers serve as a home for small insects, while the male flowers furnish pollen which is carried by these insects to the flowers of the Smyrna figs. If these small insects (Blastophaga) do not lay their eggs in the gall flowers of these caprifigs the fruit falls to the ground long before it ripens.

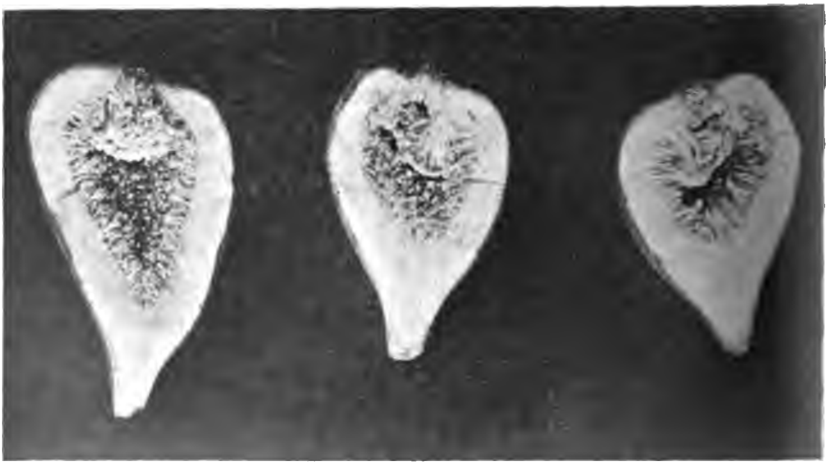


FIG. 12.—Longitudinal Section of a Smyrna Seedling Fig, Showing the Well Developed Male Flowers Immediately Around the Eye, and the Short Gall Flowers. This Type Always Drops Prematurely.

The flowers of most of the Smyrna seedlings are almost perfect reproductions of the caprifig flowers; and the presence of the same insect is required to bring the fruit to maturity. The fruit of these seedlings, as well as that of the caprifig, would seldom be edible if it did mature. Very rarely a seedling is found which produces pistillate flowers like those of the Smyrna fig and these flowers require the same cross-fertilization that is required by the Smyrna itself to bring the fruit to maturity. (See Fig. 13.)

These small Blastophaga insects have never been introduced into this State; and very likely would not survive the first winter if they were brought here. Furthermore, since the Smyrna figs can not be grown successfully here there is little need for these insects.

These seedling figs, as a rule, are absolutely useless so far as the fruit is concerned; and in this State should be destroyed at once unless wanted for shade.

The question is asked, "Where did these seedlings come from?" In nearly every instance they have been found near outhouses, or on the sites of former outhouses, where the seed of the Smyrna fig had been deposited in the excreta.

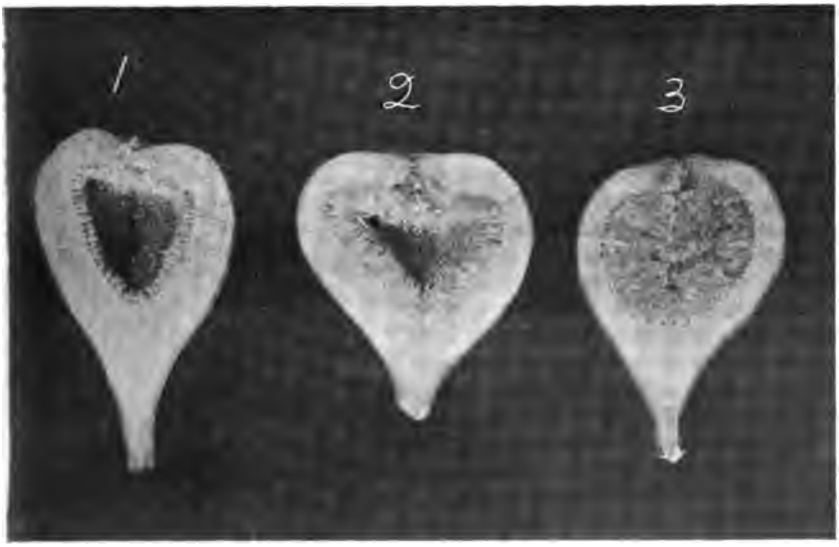


FIG. 13.—Longitudinal Sections of Three Types of Figs: 1. Smyrna Seedling with short gall and male flowers. 2. Smyrna Seedling with long female flowers. 3. Fig with interior entirely filled with crumpled *mule* flowers. Figs with flowers like 1 and 2 drop their fruit prematurely and are worthless in this State.

In a few instances the San Pedro fig had been planted which also drops practically all of its fruit when grown in the Upper South. The second or main crop of this variety has female flowers like the Smyrna and must be similarly fertilized to ripen its fruit. The first crop of the San Pedro bears *mule* flowers and the fruit develops without fertilization, but this crop is so small in this State that the variety is not worth planting.

The best advice which can be given regarding these figs is as follows: Where a fig tree habitually sheds its fruit prematurely, in the Upper South, it should be cut down without delay; then plant a tree of Brown Turkey or Celestial in its place. Do not plant the Smyrna, San Pedro, or seedlings of any variety.

It should be added that varieties which bear *mule* flowers develop their fruit without fertilization. To this class belong the only varieties worth cultivating in the Upper South; such as Celestial, Brown Turkey, Ischia White, Peau Dure, and many others. These will sometimes shed some of their fruit prematurely, but such shedding is always due to bad environment, and not to the lack of fertilization of the flowers. By proper cultural treatment such dropping can be entirely prevented.

When in doubt as to what class your fig belongs to or what variety to plant, write to this Experiment Station for advice.

INDEX.

PAGE

Cultivation 192

Dropping—

  Immature figs 203

  Cause of 204

Fertilizers 193

Figs—

  Climatic requirements of 188

  Profits in 200

Harvesting 198

Irrigation 193

Manure 193

Marketing 199

Mulching 192

North Carolina—

  Fig growing in 187

  Localities suitable for figs in 188

Planting 191

Propagation 190

Protection, Winter 196

Pruning 195

Soil 189

Training 195

Uses 200

Varieties 201

THIRTY-FOURTH ANNUAL REPORT

of the

North Carolina
Agricultural Experiment Station

of the

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

for the

YEAR ENDING JUNE 30, 1911

Including

Scientific Papers and Bulletins 209, 210, 211, 212, 213, 214, 215, 216

WEST RALEIGH, NORTH CAROLINA

RALEIGH
Edwards & Broughton Printing Co., State Printers
1912

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex-officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLINGER	Tryon
T. E. VANN	Como	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. O. ELLINGTON	Fayetteville	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Soil Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
G. A. ROBERTS	Veterinarian
R. I. SMITH	Entomologist
J. C. MCNUTT	Dairy Husbandman
J. D. CECIL	Animal Pathologist
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
F. W. SHERWOOD	Assistant Chemist
L. R. DETJEN	Assistant Horticulturist
GUY WEST WILSON	Assistant in Vegetable Pathology
T. B. STANSEL	Assistant Soil Bacteriologist
A. F. BOWEN	Bursar
LOULA V. SHERWOOD	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR.

WEST RALEIGH, N. C., June 30, 1911.

To His Excellency, WILLIAM W. KITCHIN,
Governor of North Carolina.

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1911.

Trusting that this report will prove satisfactory to your Excellency, I am,

Yours very truly,

C. B. WILLIAMS,
Director.

TABLE OF CONTENTS

Page

Board of Trustees and Station Staff 2
Letter of Submittal 4

Reports of—

Director 5
Associate Agronomist 1
Chemist 22
Vegetable Pathologist and Soil Bacteriologist 23
Poultryman 2
Horticulturist . . . . [illegible]
Animal Husbandman 30
Dairy Husbandman 33
Entomologist 34
Veterinarian 35
Animal Pathologist 37
Financial Statement 40

Scientific Papers—

Double Blossom of the Dewberry and the Blackberry 41
Preliminary Report of Investigations with the Corn Bill Bug, Particularly with Sphenophorus Callosus 51
Okra Wilt (Fusariose), Fusarium Rasinfectum and Clover Rhizoctoniose . 70

Bulletins—

No. 22—(Press Bulletin)—Use of Lime on the Farm.
No. 23—(Press Bulletin)—How to Suppress Houseflies.
No. 209—Self Sterility of the Scuppernong and Other Muscadine Grapes.
No. 210—Improved Methods for Making Cottage and Neufchatel Cheese.
No. 211—Feeding and Management of Poultry for Egg Production.
No. 212—Prevention of Oat and Wheat Smut.
No. 213—Feeding Experiments with Cows and Calves.
No. 214—Two Important Cantaloupe Pests.
No. 215—Cottonseed Meal Feeding Experiments with Mules and Horses.
No. 216—Feeding Cottonseed Meal to Draft Animals.

THIRTY-FOURTH ANNUAL REPORT

of the Director of the

N. C. AGRICULTURAL EXPERIMENT STATION

for the Year Ending June 30, 1911

BY THE DIRECTOR.

During the year marked improvement has taken place in the development of the work of the Station. Many new lines of investigation have been inaugurated and some old ones have either been completed or work on them enlarged by further study. The character and value of the work that is being carried on by the Station may be gathered from the *résumé* of the several divisions given below. This is made up from the reports of the different workers and from the personal observations of the Director.

DIVISION OF AGRONOMY.

The workers of this Division have devoted most of their time during the year to a continuation of the corn suckers and soil fertility investigations. Much data has been secured on both of these projects, which will be put in shape for publication shortly. While in 1910 in the corn suckers investigations something like sixty different varieties of corn were used, in 1911 tho work will be confined to a study of ten varieties selected with reference to their different types and their yielding powers. By this means a larger acreage can be devoted to each variety and more space given over to the suckers tests under different degrees of fertility of the soil and to the various spacing of plants in the rows. As a result of tests for three years it has been demonstrated that the production of suckers, although to a certain extent a varietal characteristic, is governed largely by the supply of available fertility of the soil. Other things being equal, the richer the soil tho larger and more complete the development of these with all varieties. On good land the removal of suckers at the ordinary time tended generally during the past three years to a smaller yield of grain and stover than from those plats of the same varieties where they were allowed to remain and develop to maturity. On the more fertile plats the suckers have, in many instances, equalled that of the main stalks in size and in production of grain and stover. The Soil Fertility investigations are being conducted with corn and cotton along the same general lines as reported last year. In all, 88 plats are in use in these investigations. To supplement this work miscellaneous fertilizer experiments are also being carried on in more detail with corn and cotton to determine the relative value of different carriers of phosphoric acid and nitrogen for these crops when planted on a clay loam soil under ordinary conditions. There are used in these experiments, with cotton, twelve plats for different nitrogenous fertilizing materials, fourteen for basic slag, and nine each for finely ground phosphate rock and Peruvian guano; and with corn thirteen plats for nitrogen carriers, sixteen for basic slag, and nine for finely ground phosphate rock. On the main fertilizer plats observations are being made to determine the effect of applications of stable manure on all the plats at stated intervals upon the actual and relative productivity of the corn and cotton, and also upon the bacterial flora of the plats, especially on the ones which have heretofore produced the minimum and maximum yields. In the study of different varieties of different crops the tests have embraced fifty-nine of corn, thirty-nine of cotton, fourteen of wheat, twenty-three of oats, twenty-six of cowpeas, twenty-one of soybeans, eleven of adsuki beans, and two of seta beans. In the corn tests Sanders' Improved, Biggs' Seven-ear, and Hastings' Prolific have stood best on an average in yield of grain; Toole's Prolific, Hope's Mexican Big Boll, Culpepper's Re-improved, Pulnot, and Wilbur Varieties of cotton were the leaders. As it has been clearly demonstrated by our tests of corn that the relative standing of the different varieties is greatly modified both by fertility of the soil and the distance given the individual plants of the several varieties, similar experiments have been started with three varieties of cotton to determine the effect of these factors upon the relative yields of this crop. Results thus far secured with corn have indicated strongly that variety tests as ordinarily carried on and the results reported do not generally have very great value to the average farmer. In the tests of varieties of wheat, Purple Straw, Harvest King. Golden Chaff, and Red May, all beardless varieties, have shown up as best yielders; while with fall sown oats, Virginia Gray and Appler have shown as some of the best in total yield of grain and hay per acre. Other oats doing fairly well are the Bancroft, Big Four, Ohio Winter, Red Rust Proof, and Czar of Russia. The Burt, a spring oat, has many good characteristics in its favor, they being fineness of straw and leaves and ease of curing. The best yielding varieties of cowpeas have been Whippoorwill, Small Black, Small Black Eye, Groit, and Iron in shelled peas; and Whippoorwill, Southdown, Black, Brabham, Iron, Clay, and Unknown in hay; and of soy beans, Mammoth Yellow, Hollybrook. Haberlandt, and Jet in seed, and Morse, Jet, Haberlandt, and Mammoth Yellow in hay. Of the varieties tested the earliest ones in date of maturity have been White's Early Prolific, New Era, Early Unknown. Small Black, Small Black Eye, and Large Black Eye with cowpeas; and Jet, Guelph, Amherst, Kingston, Ebony, and Haberlandt with soy beans. All the early varieties of soy beans except Ebony are unsuited for picking, as they ripen unevenly and shatter badly upon becoming ripe.

With adsuki beans promising results were secured during the past fall, in fact the yields of seed per acre were better from these than from cowpeas. They require ordinarily a longer time for maturity than cowpeas, but a less number of days than soy beans, it requiring last year less than one hundred days from planting to maturity. The results with two varieties of seta beans have been very promising as the plants have grown luxuriantly and fruited fairly well.

During the past two years coöperative variety experiments with corn and cotton have been conducted by the Station with a good many farmers in different portions of the State. Very striking results were secured last year in the different sections as showing the adaptability of different varieties for different soils. Sanders' Improved, Biggs' Seven-ear and Weekley's Improved varieties of corn and Cook's Improved, Toole's Prolific, Peterkin's Improved, King's Improved, Culpepper's Improved, and Excelsior Prolific varieties of cotton proved the best yielders in the hands of the farmers conducting the tests. Up to the time this work was undertaken very little field work out in the State had been done in a systematic way to call the attention of our farmers to varietal adaptations of different crops to different soils and sections of North Carolina. Feeling that this work, when carefully carried out, would be of great benefit to the farmers, considerable time has been spent in planning and getting it started in the best manner possible under the conditions. The Coöperative Tillage Experiments with the Office of Farm Management, Bureau of Plant Industry, started last year, are being continued this, all being planted in corn this year again to secure basic yields during two years for each plat before attempting a study of the effects upon the yields of different crops of various methods of preparation and cultivation of the soil. Two hundred and sixteen plats have been laid off and plotted for this particular phase of work. The experiments planned to determine the value of grain taken from different portions of the ear for seed purposes have shown that plants produced from grains from the middle of ears have yielded the highest amount of shelled corn per acre.

The breeding experiments with cotton and wheat mentioned in the last report have been continued during the year. The work has now progressed to that point at which the progeny from some of the crosses is of sufficient amount to plant a sufficient acreage in the experimental grounds given over to the variety tests to compare the relative value of the new strains as yielders in comparison with established and well known varieties of these crops being tested.

In the general farming operations of the Station cotton, corn, oats, wheat, rye, cowpeas, clovers, vetch, soy and velvet beans are being grown and during the year a systematic crop rotation has been arranged for the whole farm, in which most of these enter, the legumes and small cereals as cover crops at as frequent intervals as practicable. The rotations are so planned that they will afford field data of considerable practical value.

Outside of the purely experimental work this Division will this year have under its charge 18 acres in cotton, 34 in corn, 32 in oats, about 50 in cowpeas, and a few in soy and velvet beans. The crop production from the farm was larger with most of the crops during the fall of 1910 than it has been during any year of the encumbency of the present Director. Much new equipment in the way of mules, a horse, wagons, single and double disk harrows, riding cultivators, two-row planters, grain drills, gang and other plows, has been added.

DIVISION OF CHEMISTRY.

During the year most of the time of workers of this Division has been devoted to aiding in extending and carrying on work in connection with the Soil Bacteriology and the cottonseed meal toxicity investigations.

For the latter investigations 21 different kinds of feed have been prepared for feeding experimentally to 193 rabbits. The analytical work in connection with these experiments has required the making of 113 determination on samples of cottonseed meal and 4 of urine. Guinea pigs and hogs have been fed Sea Island cotton seed and meal, and hogs and rabbits varying amounts of sodium pyrophosphate. Both the seed and pyrophosphate have been found to be toxic to rabbits when fed as much as a grain per day, but with eighty-pound hogs receiving a quantity equivalent to the total phosphoric acid in a pound of cottonseed meal per day mixed with three pounds of red-dog flour they have made substantial gains since November 14, when they were started on the feed, up to the present (May 24), without showing any ill effect from the pyrophosphate. Residues from treatment with various extractive agents on upland cottonseed meal when fed have all been found to kill guinea pigs, although they contained inappreciable quantities of pyrophosphate. It is expected to close up much of this work during the summer, possibly before the end of the fiscal year.

This Division has coöperated with the Bacteriological Division in activity carrying forward the studies in soil bacteriology. In connection with the Bacteriological Soil Survey of the State, nitrification and denitrification studies, 2,687 determinations on 1,014 samples were made during the present year. Results of far-reaching value are being secured from these investigations.

Because of the seeming unreliability of two of the chemical methods used commonly for estimating quantitatively different forms of nitrogen, some attention has been devoted by the Division to a laboratory study and improvement of the Tiemann-Schulze method for determining nitrogen and the phenol-disulphonic acid method for nitrates.

Other chemical work has been done by this Division during the year on experimental fertilizing samples for the Agronomic Division, on reference samples for the A. O. A. C., and on a few miscellaneous samples for farmers. Several scientific papers embodying some of the results of the work of the Division have been prepared and published since the last report.

During the early part of the summer the Division will move into new and commodious quarters on the third floor of the new Engineering Building.

DIVISION OF PLANT PATHOLOGY AND BACTERIOLOGY.

The energies of this Division have been exerted mainly along the same general lines as previously reported. During the year, the experiments with tobacco to secure wilt resistant strains have been greatly enlarged by entering into coöperative relations with the National Bureau of Plant Industry. New work has been started in a badly wilt-infected field near Creedmoor, and also with some of the same soil placed in cylinders settled in the ground at the Station farm and at Creedmoor. In all 93 cylinders (2 feet by 2½ feet) are in use, 73 at West Raleigh and 20 at Creedmoor. The experiments embrace a study of different treatments of soils to determine the effect of each upon the development of the parasite responsible for this disease. Soil disinfectants, acid and neutral chemicals, different rotative systems and bacterial cultures are being used in the investigations. A study of the value and wilt resistance of selections from the strains of previous years has been continued. The work on lettuce sclerotiniose has been carried on with quite satisfactory results. The Station lettuce beds in which 45 per cent of the plants were rendered unfit for market purposes in 1909 by the ravages of this disease have been rid of it through systematic treatment, based upon life history studies, to such an extent that in the springs of 1910 and 1911 less than one-half of one per cent of the plants in the beds became affected. The method is so simple and inexpensive relatively, that it would seem to be of the highest practical value. The results of these experiments have been brought together in bulletin form for publication.

The breeding experiments with watermelons that have been conducted during the past two or three years at Auburn coöperatively with the Bureau of Plant Industry have been continued during the year. Greater resistance of plants and higher commercial and edible qualities of melons have been secured than heretofore. During the year the apple canker, okra wilt, and a buckwheat disease have been studied particularly. All these diseases are of a serious nature and any information secured with reference to their life-history development will be found useful in working out means of eradication or control. A larger portion of the time of this Division, however, has been devoted to a continuation of the studies on nitrification. In a bacteriological soil survey of the State much data has been secured on the nitrifying and ammonifying powers of North Carolina soils and the relation these sustain to soil fertility.

Small control plats with different crops are being used to study the relative value of nitrate and ammoniacal nitrogen. Experiments are also in progress to determine the effects of the presence of various species of bacteria on the activity of nitrifying bacteria.

The studies on denitrification in the soil have been enlarged and continued during the year, especially those with reference to the danger of loss of nitrates in the presence of large quantities of organic matter in the soil. Some of the plats used by the Division of Agronomy in its soil fertility work are being studied bacteriologically by this Division; especially with the ones producing the highest and the smallest yields of cotton and corn per acre.

DIVISION OF POULTRY HUSBANDRY.

The main work of this Division has consisted chiefly in conducting various feeding experiments, carried on in duplicate under different yarding conditions, and incubation work in connection with these. Of this work, most of it has been embraced in two series of four pens each. The corresponding pens in the two series having been fed the same feed or a mixture of feeds, hence the differences shown between the series, each taken as a whole, would be due to yarding conditions. Fowls in Series I were enclosed in yards set in Bermuda grass and were less than one-fifth the size of those used in Series II, which were seeded in oats during the early fall, about two months before the experiment began.

The feeds used in the corresponding lots were whole corn alone; whole wheat alone; equal parts of whole corn and wheat, with a mash made up equally by weight of corn meal, wheat bran, and cottonseed meal; and equal parts of whole corn and wheat, with a mash of equal weight of corn meal, wheat bran, and an equal part of a mixture equally of bone and meat meal. In each pen were ten females and one male bird. Monthly weighings have been made of all individuals and a record kept of the eggs laid and feed consumed by each lot in both series of experiments with the two series. The larger and cheaper egg production this winter and spring has been secured by those fowls running on growing oats, while with the feeds, the mixture containing the meat and bone meal has been shown to be most economical in both series. The eggs from each of the pens in both series have been incubated separately and records kept of the hatchability and viability of chicks from each lot. It is proposed to put a portion of the progeny from hens in the different lots back under the respective yarding conditions and feeds next winter and spring, in order to determine the effects of these upon the progeny from year to year.

During the summer it is proposed to continue the feeding experiments with skimmilk in the same general way as conducted last summer. During the year there has been considerable demand upon the time of the Poultryman in the way of correspondence on poultry matters and lecture work at Farmers' Institutes, Short Courses, Girls' Poultry Clubs, and other meetings.

A bulletin on the "Feeding and Management of Poultry for Egg Production" has been prepared by the head of this Division and published during the year.

In all the work of the Division an effort has been made to study and emphasize the useful market qualities of birds and minimize the mere show qualities.

DIVISION OF HORTICULTURE.

The efforts of this Division have been confined largely during the year to work in connection with the investigations on double flower and self-sterility of blackberries, dewberries, and muscadine grapes. In the double flower studies the resistance of different varieties of blackberries and dewberries to this trouble has been determined. The effects of different methods of pruning, spraying with Bordeaux mixture is being studied in the field. An effort was made to determine the relation, if any, the premature dropping of the leaves by the presence of leaf spot and anthracnose as well as attack of aphids had on the development of this abnormal growth. In the laboratory work was conducted designed to work out the life history of any fungus that is present and might cause the double flower. These studies have led to the isolation and identification of the causal fungus as one of the Fusariums. Certain phases of this work will be continued during the year.

The self-sterility investigations with blackberries and dewberries have developed along the same general lines as previously reported, and the results of work of the year have, in a general way, confirmed those of previous years. Considerable time has been devoted to a determination by field and laboratory methods of the self-sterility and self-fertility varieties of these as well as ascertaining whether self-sterile varieties produce pollen suitable for pollinating other self-sterile varieties. In all cases the pollen from self-sterile varieties has been found to be active and will pollinate the ovules of other self-sterile varieties. Of the fourteen varieties of dewberries and twenty-three varieties of blackberries under experiment, eight of the former and two of the latter have been shown to be self-sterile. Four or five of dewberries and twenty-one of blackberries are self-fertile.

During the year self-sterility studies have been carried on also with ten species of muscadine grapes, the major portion of the work having been with the Scuppernong, Mish, James, Thomas, and Flowers. Work thus far has indicated that all cultivated species of the muscadine group are unable to set fruit unless pollen from a male vine of the same species is provided at the proper time, as their pollen is sterile. One wild vine, however, has been found near the Station farm that appears to bear self-fertile flowers. A microscopic study of the pollen from many cultivated and wild vines has been made, to determine if any light can be shed on this important matter.

During the progress of this experiment many hybrids have been produced. These are being used in working out the laws that operate in the production of different species of the muscadine family with different colored fruit. Many hundred seedlings, as a result of last year's crosses, are under observation in the nursery row and greenhouse. Self-sterility and self-fertility studies have also been started with native and Japanese varieties of persimmon.

During the year a bulletin on the "Self-sterility of the Scuppernong and Other Muscadine Grapes" has been prepared by the Division and published.

DIVISION OF ANIMAL HUSBANDRY.

The time of this Division has been taken up largely with work in connection with the cottonseed meal toxicity investigations which are being conducted jointly with the Chemical, Animal Pathological, and Veterinary Divisions. Although most of the work is being carried on with rabbits and guinea pigs, twenty-four hogs have been fed experimentally during the year in furtherance of this investigation. A comparison has been made of the relative toxicity of Sea Island and ordinary upland cottonseed meal, with results indicating the former to be equally as harmful when fed to swine for prolonged periods as is the latter. Many extracts and residues of the meal have been fed to hogs, rabbits and guinea pigs under control. To hogs weighing 100 to 125 pounds the amount of meal fed has varied from 1 to 1½ pounds per day. On May 1 experiments were started with young pigs to see if immunity to the toxicity of cottonseed meal could be established by feeding the meal in very small quantities while the pigs are young and gradually increasing the feed as they grow older.

Feeding experiments with cottonseed meal to farm-work stock have been finished during the year and put in form for publication. The results of these experiments show that one pound of meal may generally be substituted for 1¼ pounds of corn in a ration for mules and horses, but that the meal should never be more than 12 to 15 per cent of the ration. In experiments, where such substitutions have been made, while the general health of the animals has been good and the working efficiency normal, there was no saving generally in the cost of the ration considering the prevailing prices of these feeds. During the past two winters car load lots of steers have been fed experimentally to determine the relative value of cottonseed hulls, corn-stover, silage and a mixture of the last two roughages with large quantities of cottonseed meal as the sole concentrate for finishing beef cattle. Considering the prevailing prices of these roughages in this section it was found as an average of two years results that the cheapest gains were made by the steers fed on corn silage as the roughage, and cottonseed hulls stood next. Those lots fed on corn silage alone and a mixture of silage and stover dressed out about 2 per cent higher each than those receiving cottonseed hulls as the roughage. The grazing experiments with hogs on a succession of green crops have been enlarged and continued during the year. Beginning in the early winter with fall-sown oats or rye, spring-sown oats and Canada field peas and rape alone or with early spring-sown oats for late spring, followed by cowpeas or soja beans, and later, peanuts or sweet potatoes, a succession of crops is provided for the hogs throughout the entire year. The swine-grading experiments are being continued along the same general lines as previously reported. During the year several pure-bred Berkshire hogs and Shropshire sheep have been secured by purchase.

In addition to the bulletin mentioned above this Division has prepared another one on "Selection and Feeding of Beef Cattle." Some additions have been made to the equipment of the Division which will add materially to its working efficiency.

DIVISION OF DAIRY HUSBANDRY.

During the latter part of last year the Station lost its Dairy Husbandman through resignation. The present encumbent assumed his duties on September 1 last. He, after familiarizing himself with the previous work of the Station along dairy lines, planned and started some cottonseed meal feeding experiments with heifers and young calves to determine its effect upon their health and general development. Twelve heifers, ranging in age from 5 to 10 months, were selected for the work and divided into two lots of approximately equal age and size. These lots were fed mixtures of equal parts of corn meal, oats, and wheat bran, and equal parts of cottonseed meal, oats, and wheat bran, respectively. Both lots were fed the same roughage, consisting of a mixture of corn silage and hay. Heifers which were ten months of age have been able to handle the ration containing cottonseed meal to the extent of one pound per day, but those ranging from five to seven months old have either lost or made practically no gains. The lot fed on the corn-oat-bran ration are thrifty and have made rapid gains. Observations are being made to determine the actual cost of raising heifers on different feeds and combinations from birth to the time they come into milk. Skimmilk will constitute the basis of the ration for the first fourteen weeks. Linseed meal, Schumacher calf meal and grain consisting of a mixture of equal parts of corn meal, oats and wheat bran will be combined with the milk in the different rations to determine their relative cheapness as feeds for young stock. Other feeding experiments with Bovita and other cottonseed meal and hull mixtures, using the dairy herd of the college, were started during the latter part of May. A bulletin by the Dairy Husbandman on the feeding and management of the dairy herd will be finished for publication about the middle of June. In all the experimental work of this Division the college dairy herd, consisting of about sixty animals, has been used.

DIVISION OF ENTOMOLOGY.

The Entomologist was concerned during the fall principally with a study of the habits and life history of two melon worms. The work was conducted chiefly at West Raleigh and in the cantaloupe growing sections of Robeson, Scotland, and Columbus counties. Results thus far secured show that ordinarily the early crop of cantaloupes is affected but little by these pests, and that late sowings may be grown without much injury, if summer squash is used properly as a trap plant. The results of the investigations indicate that cantaloupe growers must depend largely upon early crops, proper cultural methods, rotation of crops and the use of trap plants.

One of the species of melon worms studied does not seem to make its appearance in the fields in injurious numbers in North Carolina until after the maturity of the cantaloupe crop. This species is also rendered of slight economic importance by its parasitic enemies.

The corn bill bug has been reported in damaging numbers from many of the coastal plain counties during the year. Three species of this bug have been taken during the year, one of which has done practically all the damage to the crops.

During the fall some preliminary life history studies were carried on with this pest, and this work will employ the Entomologist chiefly during the spring, summer and fall of 1911. A study will be made of habits, food plants, hibernation, generations, and activities of this pest. Work of the Entomologist so far has shown that the bill bugs breed in young corn and in certain species of grass growing in lowlands.

Observations on bill bugs under control indicate that they hibernate in the soil. The Entomologist has made general notes and observations on other injurious insects occurring in the State. Many specimens have been collected and preserved. A bulletin on "Two Important Cantaloupe Pests" has been prepared during the year by this Division and published. In this bulletin are embodied many of the observations and results secured in the investigations that are being carried on with melon worms.

DIVISION OF VETERINARY SCIENCE.

As in previous years, the major part of the work of this Division has been expended in a furtherance of the investigations that are being conducted by the Station to determine the cause or causes for the fatal results usually following the feeding of cottonseed meal to swine beyond a certain quantity and period. The Veterinarian, during the year, has aided in conducting autopsies on more than sixty animals. He has found that the characteristic antemortem symptoms of cottonseed meal poisoning has developed in hogs in from 6 to 20 weeks, the length of the time before their appearance being governed by many factors, such as age and individuality of animals and amount of meal fed per day as well as methods of feeding. In all cases with hogs after a time of feeding with cottonseed meal the feces become hard and compact.

On October 6 a calf and pig weighing 175 and 95 pounds respectively were started on a feed of cottonseed meal, each receiving 1 per cent of his body weight of meal per day. This was continued until February 10, when the feed of meal was increased to 1½ per cent of original body weight; and on April 20 the ration to the calf was increased to 2 per cent, but the pig has remained on a feed of 1½ per cent of weight as he has refused to eat a larger amount. Although the pig and calf have made fairly good gains (up to May 25), they do not present a thrifty appearance.

The ante-mortem observations and autopsic revelations have coincided with those of the previous year, in the cottonseed meal investigations. The Veterinarian has had, during the year, an increased number of enquiries with reference to the diagnosis and treatment of various animal diseases.

DIVISION OF ANIMAL PATHOLOGY.

This Division of the Station was created a year ago because of the urgency for more pathological work at the time in connection with the cottonseed meal feeding investigations with swine, rabbits and guinea pigs. On September 1 the new Pathologist entered upon his duties and during the year practically all his Station time has been taken up with work on the cottonseed meal project. The Animal Pathologist has been especially helpful in putting the experiments in better shape. The stock room and caging of the small animals used in the investigations have been greatly improved. The old quarters and system of caging were found unsatisfactory. New cages have been provided and a special room for the animals has been secured on the third floor of the new Engineering Building, near the new quarters provided for the Chemical Division of the College and Station.

The Pathologist is now making detailed daily observations on all animals used in the experiments. An effort is being made to determine the exact pathological changes that take place in the various organs and tissues of animals dying of cottonseed meal poisoning. Experiments have been started to determine if the small animals used in the investigations can be fed in such a way and manner as to become immune to the harmful effect of the meal feeding. It has been planned to make a chemical and microscopic study of the blood of all animals succumbing to the effects of the meal, and to ascertain if auto-intoxication is produced. Various feeds, extracts, residues, etc., have been fed during the year, both forced and naturally. Specimens are preserved from all autopsies for histological studies.

The Pathologist has devoted some extra time to fowl cholera studies, especially on vaccination against this disease. The results have been encouraging.

NEW BUILDING AND EQUIPMENT.

Commodious and well lighted quarters have been provided by the College for the Station laboratories, store-rooms and offices of the Chemical Division on the third floor of the new Engineering Building. This will be occupied as soon as the necessary plumbing and carpenter work is completed. New and better laboratory apparatus has been secured during the year by all the Divisions having laboratories. The farm equipment has been materially improved and increased through purchase.

BULLETINS.

Bulletins have been issued during the year as follows:

No. 209.—Self-sterility of the Scuppernong and Other Muscadine Grapes, by F. C. Reimer and L. R. Detjen.

No. 210.—Improved Methods for Making Cottage and Neufchatel Cheese, by John Michels.

No. 211.—Feeding and Management of Poultry for Egg Production, by J. S. Jeffrey.

No. 212.—Prevention of Oat and Wheat Smut, by F. L. Stevens.

No. 213.—Feeding Experiments with Cows and Calves, by John Michels.

No. 214.—Two Important Cantaloupe Pests, by R. I. Smith.

No. 215.—Cottonseed Meal Feeding Experiments with Mules and Horses, by R. S. Curtis.

No. 216.—Feeding Cottonseed Meal to Draft Animals, by R. S. Curtis.

No. 22 (Press Bulletin).—Use of Lime on the Farm, by C. B. Williams.

No. 23 (Press Bulletin).—How to Suppress Houseflies, by R. I. Smith.

REPORT OF DIVISION OF AGRONOMY.

The following statement reports the work of the Department of Agronomy for the year ending June 30, 1911, giving the general progress of the field experiments and their present condition.

VARIETY TESTING.

Corn.—The usual variety test of corn was continued this year and embraced 59 varieties in connection with which were carried on the experiment with suckers. From the part of the experiment concerned with suckers the results of 1910 are generally in line with those of 1908 and 1909. Field counts, measurements and weights of suckers sprouted under different conditions of soil fertility show conclusively that their production, maintenance and development depends mainly upon the amount of plant food with which the main stalk is supplied. On soil made very rich a rank growth of suckers sprouted and reached maturity, many of them equalling the main stalk in size and productiveness; while on the poor soil only a comparatively insignificant number made their appearance and among these there was rarely any development beyond the stage of being merely an appendage at the base of the main stalk.

The 1910 results as to the relation between the removal of suckers and lessening in total value the yield are partly in accord with those of former years. On rich land with the plants distanced 30 inches in the row there was a considerable loss caused by removing suckers, but on land of similar fertility with plants spaced 20 inches in the row there was a slight gain in combined value of grain and stover. Among the varieties Sanders' Improved, Biggs' Seven-ear, and Hasting's Prolific have a higher average rank for all conditions than any other variety.

Cotton.—The 1910 variety test of cotton carried 39 varieties. Wilbur No. 1 and Wilbur No. 2, tested for the first time, made a very good showing, taking first and second place in combined value of lint and seed. A few varieties have done well for more than one year. Toole's Prolific, Hope's Mexican Big Boll, Culpepper's Re-improved, Triumph, and Pulnot have maintained a high average rank through two and three years of testing. In addition to the comparison of varieties with respect to their actual monetary value, an intimate and detailed study is being made of their characteristics with the hope of discovering correlations between yield and superiority along more narrow lines.

Wheat.—The variety test of wheat has been carried though five years, 1906-1911, and from ten to fifteen varieties have been under experiment each year, but until 1910 the department did not possess the threshing equipment necessary to secure accurate and hence reliable results in yield of threshed grain. The threshing had been previously done by hand, a very crude process which was necessarily accompanied by considerable inaccuracy. With the purchase of a small threshing machine, however, for the experimental wheat and oat crops of 1910 this liability to error through the threshing process has been elminated, and for the past two years thoroughly reliable results have been secured in yields of grain. Among the fourteen regular varieties tested last year the three best were Purple Straw, Currell's Prolific, and Red May. Purple Straw, notwithstanding the crude method of threshing to which the varieties have previously been subjected, has been rather consistently at the front, standing among the three best yielders of grain three years out of the four, and ranking well above the average in the other year. Harvest King, Golden Chaff, and Red May have also proven to be excellent varieties during the four years test. The test for 1910-1911 included also three selections from the plant breeding plats. These strains have been grown from individual plant selections made in 1908 from Leap's Prolific, Golden Chaff, and Tuscan Island. The selections from Leap's Prolific and Golden Chaff appear very promising in the light of the first year's test as they not only exceeded in yield of grain the parent varieties, but also stand at the head of all varieties in the test. The selected strain from Leap's Prolific was first in yield of grain and that from Golden Chaff third.

Oats.—The work with oats last year was a test of twenty-three fall sown varieties. These were the survivors of an elimination by which less worthy varieties fell from the large list grown from 1907 to 1909. Among these varieties the leaders in threshed grain for the past season are Red Rust-proof, Appler, Burt, Bancroft, Virginia Gray, and Culberson, in the order named. For purposes other than yield of grains the Burt variety has many good points over all others tested. It has a good lead over any variety known at this Station for earliness of maturity and can be harvested either for hay or grain in ample time for cowpeas or ensilage corn. It is also a much better variety for hay than many others, having a taller, finer straw which is easier to cure and probably more cleanly eaten by stock than the coarser stemmed kinds.

Peas and Beans.—In 1910 twenty-six varieties of cowpeas, twenty-one varieties of soy beans, eleven varieties of Adsuki beans, and two varieties of Seta beans were tested for comparative yields and to afford a study of varietal characteristics. As it was possible last year to give only a small area to each variety the whole of each plat was reserved to determine yields of grain instead of cutting part for hay, as has been the custom. Whippoorwill was again at the top in production of shelled peas, yielding 18.5 bushels per acre. Blackeye was the first to ripen fully, although New Era and Early Unknown were only a few days later. The India cowpea appears to be an excellent variety for hay. It grows luxuriantly, holds its leaves well and yields with considerable prolificacy a small-podded, well filled fruit, although it is not a heavy yielder of shelled peas. The India cowpea is a small-stemmed, erect to half-trailing sort. In 1910 Townsend, Unknown, and Peerless fruited very poorly, the two latter varieties being nearly barren.

Among the varieties of soy beans in 1910 Hollybrook, Haberlandt, and Jet were in the lead, 22.9, 22.5, and 19.5 bushels per acre. Jet, Guelph, Ebony, Amherst, Kingston, and Haberlandt are the earliest maturing varieties. Mammoth Yellow is a better variety for hay than any of the others. Jet, Amherst, Kingston, Haberlandt, and Guelph do not ripen uniformly and on this account it is practically impossible to gather all their seed because the pods that are more forward in ripening split and shatter their seed before the other pods mature. These varieties would make an excellent pasture for hogs. They grow in short, thick, heavily fruited bunches, and if planted with a drill or broadcast would make a very heavy yield of seed.

The Adsuki beans were heavy hay yielders in 1909, but produced seed very lightly on account of late planting. However, in 1910 the yield of seed greatly increased and were considerably heavier than yields of the cowpea varieties. No. 17851 yielded 22.9 bushels per acre, while 16791 and 17847 gave 20.2 bushels each. The seed of Adsuki beans matures in about 95 days, which is rather later than cowpeas and considerably earlier than soy beans.

Seta beans, Nos. 21291 and 18444, would have been splendid yielders of hay. The first had a heavy foliage but did not fruit so thickly as the second, which, although of lesser growth, was luxuriantly fruited.

FERTILIZER TESTING.

Main Plats.—The main corn and cotton plats in Soil Fertility Investigations were continued during the past year under a slight modification.

The 1910 results are in general accord with those of former years for cotton, but are somewhat at variance with previous results for corn. With cotton the heavier applications of nitrogen and phosphoric acid give relatively higher returns in value of increase over the cost of the fertilizer than do the normally fertilized plats, or those receiving less than a normal application; but with corn, in 1910, the lighter and less expensive applications are found to be the most profitable. In fact some of the formulas giving the best returns are those in which the expensive element nitrogen has been left out altogether in the application of commercial fertilizer. This may be accounted for by the fact that nitrogen was supplied cheaply and sufficiently in the stable manure, therefore the least expensive application of fertilizer which supplied enough phosphoric acid and potash for the needs of the crop was the most profitable.

Rotation, distance, and culture tests for both corn and cotton have been included in these main fertilizer tests, but their results can be stated only in a more detailed report of the whole experiment.

Phosphate Slag.—The phosphate slag test with cotton was continued last year on the old alfalfa sod. Heavy applications of phosphoric acid and nitrogen gave increased yields, but not in the proportion that may be expected later when the natural fertility of the soil, due to a good supply of organic matter from the alfalfa stubble, is depleted. It is noticeable in the results of this year that lower relative yields were made by plats that did not receive an application of potash in combination with phosphoric acid and nitrogen.

In the slag tests with corn heavy applications of phosphoric acid and nitrogen generally gave increased yields. As with cotton, however, the phosphoric acid and nitrogen seem to give better results when combined with potash since the yields resulting from increased applications of these elements are very often relatively lower when potash is not supplied.

Phosphate Rock.—The usual tests of ground phosphate rock with corn and cotton were carried on last year. From the corn tests the results indicate that while increased applications of phosphoric acid and nitrogen over the normal formula made slightly better yields, the difference was not great enough to justify the increase from an economic standpoint. With cotton, the plats receiving an application of stable manure with Phosphate Rock gave higher yields than the plats that received their nitrogen in the form of dried blood. Two tons of stable manure per acre in combination with 160 pounds of phosphate yielded over 100 pounds more lint per acre than did 204 pounds of phosphate rock in combination with 144 pounds of dried blood.

Miscellaneous Fertilizer Test with Corn and Cotton.—This test is conducted to ascertain the fertilizing value of the various new fertilizing materials that are being put on the market. Under test last year were Solubilized Organic Nitrogen, Potash Manure, Beet Refuse Compound, and Calcium Cyanamid. These were tested in comparison with the better known nitrogenous materials, Dried Blood, Sulphate of Ammonia, and Nitrate of Soda. In production of shelled corn per acre Beet Refuse Compound, Sulphate of Ammonia, Calcium Cyanamid, and Potash Manure gave better results than Dried Blood, Solubilized Organic Nitrogen, and Nitrate of Soda. With cotton the plats receiving an application of Nitrate of Soda, Sulphate of Ammonia, and Dried Blood yielded more lint per acre than any of those treated with the new materials.

Peruvian Guano.—Fertilizing tests with Peruvian Guano alone and in combination with other fertilizing materials were continued in 1910. An application of Peruvian Guano alone at the rate of 250 pounds per acre almost doubled the yield of cotton when checked against a plat receiving no fertilizer. An application of 500 pounds per acre produced more cotton by about one-fifth than the application of 250 pounds. In combination with 37 pounds of Kainit, 97 pounds of Acid Phosphate, and 130 pounds of Nitrate of Soda per acre, 110 pounds of Peruvian Guano more than doubled the yield per acre of the plat receiving no fertilizer.

Top Dressing.—Top dressing experiments with Nitrate of Soda and Sulphate of Ammonia were conducted in 1910 on wheat and corn. The application of both these materials on wheat followed a spring treatment of 200 pounds of Acid Phosphate and 25 pounds of Muriate of Potash per acre. The difference in yield between plats receiving only Acid Phosphate and Muriate of Potash and those receiving an additional treatment of Nitrate of Soda or Sulphate of Ammonia was very slight when only 100 pounds of Sulphate were added. However, when 200 pounds of either Nitrate or Sulphate were applied the results were more marked, with Sulphate of Ammonia causing slightly better yields. An application of Sulphate of Ammonia on corn at the rate of 100 pounds per acre, June 27, increased the yield per acre by between four and five bushels of corn and three hundred pounds of stover.

Variety-Distance.—This test has been conducted with cotton since 1908, but it is discontinued in 1911 and the land it previously occupied given to an experiment investigating the correlation between soil fertility and types of cotton. Previous to 1910 the varieties used in this work were Culpepper's Improved, King's Improved, and Columbia Long Staple, but last year seed of only Culpepper's Improved and Cook's Improved could be secured in sufficient quantity for planting the test; therefore, the test was limited to a comparison under different distances of planting between these two varieties. The relative yields of these two varieties were not nearly so stable as has been the case with the three varieties previously grown. At 15 inches and 21 inches, Cook's Improved gave the best yield; but at 12 inches, 18 inches, and 24 inches, Culpepper's Improved was the better yielder of the two.

Coöperative Variety Tests.—Coöperative variety testing of corn and cotton was begun in 1910 and gives promise of developing into a very interesting and beneficial line of work. Eight varieties of corn and seven varieties of cotton were selected from the large list of varieties grown on the Station farm and were placed with county demonstration agents for distribution to farmers for a test. Nine tests of corn were made that may be considered fairly satisfactory and reliable.

The results of these are somewhat remarkable in that two varieties, Sanders' Improved and Biggs' Seven-ear, so consistently took such a high stand among the other varieties sent from the Station and the native varieties which were usually included in the test. In four tests Sanders' Improved stands at the head and is third, fourth, sixth, and seventh in the remaining tests. Biggs' Seven-ear is three times a leader. and is second twice, third three times, and fourth once in the nine tests. The results from tests of cotton varieties are not nearly so satisfactory as are those from corn. Tested only four times the results are not sufficiently substantial to mark any variety as a consistent performer. although Toole's Prolific and Cook's Improved made a very good showing.

Coöperative Tillage Tests.—This work was begun in 1909 in coöperation with the Office of Farm Management of the U. S. Department of Agriculture. Considerable land is devoted to this work and includes 144 one-twentieth acre plats located in the Method field and 72 one-twentieth acre plats just northeast of the barn. The work has as yet only progressed so far as to secure basic yields to be used as checks for all the plats when the tillage experiments begin. These yields have been secured with both corn and cotton from the Method field and with corn only from the field near the barn. Two years results in growing basic yields in the Method field plats show a considerable variation in their relative production of corn and cotton. This field is again in corn in 1911.

Planting Seed From Various Parts of the Ear.—This experiment, designed to study the effect of a continued seed selection from certain parts of the ear upon the resulting progeny, has been in progress for three years. From last year's crop, the third successively planted from the butts, tips, middles, and all parts of the ear, the tabulated results show that ears grown from seed from the butt and tip parts of the ear have a decidedly lower percentage of grain than those grown on the plats planted with seed from the middle and from all parts of the ear. The plat planted with seed from the middle of the ear produced more shelled corn but not so much stover as the butt and all-grain plats.

There are other slight differences in yield and characteristics, but they are not sufficiently marked to be considered permanent.

Stability in Weight of Seed Cotton After Picking.—An experiment was designed and carried out in 1908 and 1909 to learn if there was any loss in the weight of seed cotton after picking, when kept stored for some time, and if so, whether the loss occurred from the seed or lint. Close attention was also given to the lint to see if there was any change in its length or tensile strength. As the experiment was conducted rather superficially during these two years no very substantial results were obtained. It was not carried during 1910 on account of lack of time, but will be resumed in the coming fall on a scale broad enough to substantiate whatever results may be secured.

PLANT BREEDING.

Seed Selection with Cotton.—This work begun with cotton in 1908 includes individual plant selections made from the general crop and variety plats of that year for length of staple, earliness, prolificacy, size and uniformity of bolls, double and triple-bolled plants, and for combinations of some of these characteristics. The selections were made with the idea of obtaining improved strains of the parent varieties and to secure good parent stock for cross-breeding, by which method a trial will be made to produce new and desirable varieties. Some very fine plants were produced in 1909 and 1910 from the selections, and enough seed were taken from them for a trial with other varieties in the variety-test of 1911. Culpepper's Improved, the variety grown in the main crop, is under improvement by seed selection. In the breeding plat of this year enough seed will be grown to plant several acres in the main crop of 1912. Several crosses were made by a cross-pollination of the improved strains in 1910, the aim being to combine prolificacy with the non-dropping tendency and general vigorousness shown by some of the improved stock. Most of the crosses were successful and seed from them will be planted and selection begun from their progeny for the desired characters.

Seed Selection with Wheat.—The work with wheat is similar in outline to the improvement by seed selection with cotton. The original selections made in 1908 have been continued and enough seed were secured from the most promising ones in 1910 to plant several plats for trial in the variety test. Selections from Leap's Prolific and Golden Chaff are very promising strains. Given an area of one-tenth acre in the variety test this year they have made an excellent showing in yield of grain.

Respectfully submitted,

W. C. Etheridge,
Associate Agronomist.

REPORT OF DIVISION OF CHEMISTRY.

I have the honor to submit the following report of the Division of Chemistry for the year ended June 30, 1911:

During the year the Division was engaged in work along the following lines: Soil Bacteriology in coöperation with the Division of Bacteriology, Toxicity of Cottonseed Meal in coöperation with the Animal Husbandry, Veterinary and Pathological Divisions, Inorganic Plant Constituents in coöperation with the Agronomy Division, Inorganic Plant Constituents and Tannin in coöperation with the Referees of the Association of Official Agricultural Chemists, Sugar Beet Culture in coöperation with the Bureau of Plant Industry, Testing Reagents and Methods of Analysis, and miscellaneous work.

Soil Bacteriology.—The Division has made 2,687 determinations in 1,014 samples of soils and solutions as follows:

Nitrogen as ammonia by magnesium oxide method.......	62
Nitrogen as nitrates, phenol disulphonic acid method....	474
Nitrogen as nitrates, Tiemann Schulze method...........	409
Nitrogen as nitrites, Griess method....................	864
Nitrogen as nitrites and nitrates, Withers and Ray method	834
Nitrogen total by Kjeldahl method......................	20
Humus	12
Volatile organic matter................................	12
	2,687

With the Division of Biology it has published the following:

Studies in Soil Bacteriology, Nos. 2 and 3 in the North Carolina Station Report for 1908-09; Studies in Soil Bacteriology No. 4 in the North Carolina Station Report for 1909-10, and in the Centralblatt für Bakt. Band 27. The manuscript for Studies in Soil Bacteriology No. 5 is submitted herewith for publication. An abstract of it was read before the May, 1911, meeting of the North Carolina Academy of Science.

Toxicity of Cottonseed Meal.—This Division has prepared 356.9 kilograms of 17 kinds of feed for 203 Belgian hares. Twelve of the feeds had been used previously and five were used this year for the first time. In connection with it there were 161 determinations of phosphoric acid. Two important conclusions have been reached as a result of the experiments and the manuscript will be submitted for publication very soon.

Inorganic Plant Constituents.—This division has made 218 determinations in 50 samples of portions of the cotton plant sent for analysis by the Director. These determinations were:

Nitrogen total by Kjeldahl method........................	40
Phosphorus pentoxide total..............................	36
Calcium oxide total.....................................	10
Moisture	132
	218

Association of Official Agricultural Chemists.—This Division has made 14 determinations in three samples sent out for analysis by the

Referee on Inorganic Plant Constituents, and 191 determinations in the four samples sent out by the Referee on Tannin. Dr. Ray has served as Associate Referee on Tannin during the year. During the year the writer presided over the Washington meeting of the Association (November 10, 11, and 12, 1910) and as President read an address upon "The Teaching of Chemistry in American Agricultural Colleges," which was published in *Science*, vol. 33, pages 849-855, and in the Proceedings of the Association (Bulletin No. 137 Bureau of Chemistry, pages 91-97).

Sugar Beet Culture.—Experiments conducted in various parts of the United States have indicated that the most profitable areas for sugar beet culture were within the zone having a mean summer temperature of 70° F. In 1898-9 (Bulletin 180, May, 1901) the writer conducted experiments in North Carolina which resulted in producing for the first time in the State a beet containing 14 per cent of sugar, and prepared a bulletin showing the probable sugar beet areas in the State. In continuation of that work and in coöperation with the Bureau of Plant Industry of the U. S. Department of Agriculture, this Division has distributed this year sugar beet seeds to 150 residents of the 12 counties in Western North Carolina which seem best adapted to the growth of the beet.

Testing Reagents and Methods.—This work has involved 199 determinations as follows:

Moisture	12
Chlorine gravimetrically	8
Oxygen	12
Nitric oxide	15
Nitrogen as nitrates phenol-disulphonic acid	46
Nitrogen as nitrates, Tiemann Schulze	88
Nitrogen as nitrates and nitrites, Withers and Ray	8
Sulphur trioxide gravimetrically	2
Sulphur trioxide volumetrically	8
	199

During the year the writer and F. W. Sherwood read a paper before the January, 1911, meeting of the North Carolina section of the American Chemical Society, proposing a modification of the Tiemann Schulze method for determining nitrates and nitrites which has proven very satisfactory in our hands. The paper is submitted herewith for publication.

Miscellaneous.—The Division has made 83 determinations in 34 samples, as follows:

Soils	7
Feed	1
Fertilizing material	12
Water	1
Building lime	3
Marl	2
Fats	4
Guinea pig urine	4
	34

The determinations were:

Nitrogen	20
Potassium oxide	6
Phosphorus pentoxide	4

Calcium oxide	12
Magnesium oxide	2
Carbon dioxide	10
Acidity	7
Total solids	2
Volatile matter	4
Specific gravity	4
Melting point	4
Albuminoids	4
Sugar	4
	83

During the year Dr. Ray was elected Secretary of the North Carolina Section of the American Chemical Society. The writer was elected Vice-president of the North Carolina Academy of Science, and a member of the General Committee of the Agricultural Section of the VIII International Congress of Applied Chemistry.

The writer read before the Southern Commercial Congress (Atlanta, Ga., March 10, 1911) a paper upon The Relation of Climate and Rainfall to Southern Agricultural Monopolies, which was published in *The Tradesman* for March 16, 1911.

The Division is moving into the new and more commodious quarters which have been provided for it in the new Engineering Building. For this increased space and improved equipment we wish to express our thanks to you, President Hill, the Board of Trustees, and General Assembly.

Very respectfully,

W. A. WITHERS,
Chemist.

REPORT OF DIVISION OF BIOLOGY.

I beg to submit the report of the division under my charge for the fiscal year now closing:

In Plant Pathology the chief subject under investigation has been lettuce sclerotiniose. The method of treatment deduced from laboratory investigations has now been given a thorough trial in the field and proved successful. The results have been presented in practical form in Bulletin 217. A more extended exposition of the technical work and results is now in the hands of the Director, ready for publication. A popular Bulletin, No. 212, has been prepared and printed. This discusses smuts, especially those of the cereals, and gives methods of treatment. A popular article, Progress in Control of Plant Diseases, was published in *Popular Science Monthly.*

Okra wilt (Fusariose), similar to cotton wilt, was found near the college, and received some attention (page 70).

A new buckwheat disease (Rhizoctoniose) has also been the subject of study.

Hundreds of letters relating to plant disease have been received and answered. Many of these were accompanied by specimens and diagnoses were made and treatment prescribed. Work has been continued on apple and crucifer diseases.

In coöperation with the National Department of Agriculture extensive plans have been made for study of the Granville tobacco wilt and work has been begun. Work on a plant disease survey in coöperation with the National Department of Agriculture has been continued.

Breeding for Disease Resistance.—Breeding for resistance of melons and tobacco against wilts has been continued along the lines reported in previous years.

Soil Bacteriology (in coöperation with the Division of Chemistry).—The Soil Bacteriological Survey undertaken some years ago has now been completed and the results are nearly ready for publication, as are also a number of miscellaneous observations on soil bacteriology. The point receiving major attention now relates to the relative values of ammonia and nitrate nitrogen to the growing plant. This subject has been under study some years, but much work remains yet to be done. The associative action of bacteria in soil, especially of nitrifiers and denitrifiers, both with and without organic matter, is also subject of study.

Respectfully submitted,

F. L. STEVENS,

Vegetable Pathologist and Soil Bacteriologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1911:

FEEDING EXPERIMENTS.

The feeding work outlined in last year's report has been taken up. These feeding experiments are to test different rations for egg production and for their effect on the health and breeding quality of the fowls. It was planned to use 12 pens of fowls in this work, feeding six different rations. Six of the pens to be ordinary size yards, such as the average poultryman would use, and six lots of approximately half an acre each in which farm crops are grown. On account of lack of room two of the large lots could not be used and to balance the experiment two of the small pen lots were dropped, leaving eight lots of fowls on four different rations. A great many farmers still depend entirely on corn for feeding their poultry. This feed will, under some conditions and at certain seasons, give very satisfactory results, but when the fowls are dependent on the feeder for all they get to eat it will not give good results. In order to test this matter corn only was fed to one pen in each size yard. Wheat alone was fed to two pens. The two other rations were composed of both grain and dry mash. The grain was the same in each case, being two parts corn and one part wheat. The mash in one case was equal parts by weight of corn meal, wheat bran, and cottonseed meal. In the other it was four parts corn meal, four parts wheat bran, two parts meat meal, and two parts bone meal.

The small yards were set in Bermuda grass, which gave no green feed during the winter, but an abundance during the summer. To keep the grass in these lots in the best condition for the hens during the summer it was pastured just enough to keep it from getting old and tough. In the large lots winter oats was grown for hay. This crop gave good grazing during the winter months and was harvested about June 1st.

These experiments are planned to run nine months, from January 1 to September 30, and are, therefore, not completed at this time. For the winter period there was a saving in the cost of production of from twenty to thirty-three and one-third per cent in the large yards with the green crop over the same rations in the small yards. With the first three rations mentioned the saving was approximately one-third and on the last ration one-fifth.

The last ration, which contained the meat meal and bone meal, was the only one that could be considered satisfactory as with the others the eggs cost from 22 cents per dozen to 36 cents per dozen, while with this ration for the three months from January 1 to March 31, the cost was 12 cents per dozen in the large yard and 14.4 cents per dozen in the small yard.

In all cases except the meat meal and bone meal ration, the fowls in the large lots laid more eggs than those in the small lots. Those fed meat meal and bone meal in the small yard laid a few more eggs than those in the large lot, but the cost was greater and the profit less in the small yard.

The fertility and hatchability of the eggs has not been fully tested at this time, but in those incubated the results were better from the hens having the meat meal and bone meal ration than any of the others, but were not as good as they should be, even from these lots, and while the ration was fairly satisfactory from the standpoint of egg production it is thought that it might be improved for breeding purposes by cutting down the animal feed in the ration. Just what would be the best proportion considering both egg production and breeding ability has not yet been determined.

Experimental work in the feeding of growing chickens has been outlined for the summer and will be started as soon as the crops are ready. These are divided into two groups of three lots each. One to be a test of different rations on the same grazing conditions and the other of different grazing crops where the same ration is fed.

It is planned to extend the feeding experiments for the next year by the addition of more of the large lots. Some changes in the rations will also probably be made, based on the results obtained in this work.

There is a large and growing demand throughout the State for information pertaining to poultry. The Poultryman attended twenty-eight Farmers' Institutes during last summer and two short course schools held during the winter by the State Department of Agriculture, and judged the poultry at several fairs. The policy of this Division in regard to judging is to help in any way that it can the newly organized and smaller Agricultural Societies which do not feel able to pay for the services of a poultry judge.

The demand for breeding stock and eggs for hatching during the year has been the largest in the history of the Division. The correspondence which comes to the Poultryman has also greatly increased from year to year.

Respectfully submitted.

J. S. JEFFREY,
Poultryman.

REPORT OF DIVISION OF HORTICULTURE.

I herewith submit a report of the work of the Horticultural Division for the year ending June 30, 1911:

SELF-STERILITY OF DEWBERRIES AND BLACKBERRIES.

Our work on this problem has been continued during the past year, and some very important results were obtained. These results corroborate those of the previous year. We have found that the following varieties of dewberries are self-sterile: Premo, San Jacinto, Chestnut, Manatee, Rogers, White, Lime-kiln, and Monroe.

The following varieties are self-fertile: Lucretia, Austin, Cox, Ruth, and possibly Grandee.

One very interesting and important fact discovered is, that one self-sterile variety will successfully cross-fertilize another self-sterile variety of dewberry. This means that the pollen of self-sterile varieties is good, that is, it will germinate on the pistils of other varieties. It also germinates readily in a sugar solution in the laboratory. As yet we have not been able to determine why this pollen will not fertilize the pistils of the same variety. Our work on this problem will be continued.

SELF-STERILITY OF ROTUNDIFOLIA GRAPES.

We have given a large amount of our time during the past year to this problem. We have found that all the varieties of this species now in general cultivation are self-sterile; that is, the fruit can not develop unless the flowers are fertilized with pollen from a male muscadine vine. This self-sterility is due to the fact that the pollen of the cultivated varieties is worthless and can not germinate under any conditions. The results of this work have been published in Bulletin 209 of this Station.

One wild vine has been found in our work which appears to be an exception to this rule. If this vine should prove an exception it will be a valuable discovery. Our work on certain phases of this problem will be continued.

A STUDY OF ROTUNDIFOLIA GRAPE HYBRIDS.

The Rotundifolia grapes are the most valuable in the South. But in some respects they are very defective. These imperfections must be eliminated by breeding. Just how this can be done is still a question. Hence we have made many crosses, and are making a careful study of the hybrids. This is to determine the fundamental laws which govern such hybrids. We have already obtained some very valuable data; and have found one fundamental law which governs such hybrids. This law can be stated as follows: When the Scuppernong is fertilized with pollen from a white male vine the seedlings resulting from such seed will produce white fruit; and when the Scuppernong is fertilized with pollen from a black male vine the seedlings resulting from such seed will produce dark fruit.

Hundreds of seedlings from last year's crosses are just beginning to grow and some valuable data will be obtained from these this year.

SELF-STERILITY OF PERSIMMONS.

We will begin this year an extended study of self-sterility and self-fertility in Native and Japanese persimmons. This is to determine what varieties are self-sterile, what varieties are self-fertile, and what varieties or forms are the best pollinizers for the self-sterile varieties. Also to detemine the cause of seedlessness in many persimmons.

A STUDY OF THE INFLUENCE OF PLANT FOOD ON POLLEN.

In connection with our studies on self-sterility of plants we are trying to determine the influence which the elements, nitrogen, phosphorus, potash, magnesium, and calcium, have on the formation and character of pollen. At present the tomato plant is being used for this study. The work on this problem will be continued.

DOUBLE BLOSSOM OF THE DEWBERRY AND BLACKBERRY.

The work on this problem has been practically completed. We have found that this trouble is due to a fungus disease, known as *Fusarium rubi,* Winter. The results have been prepared for publication.

Certain phases of the subject, such as a study of varieties subject to the disease, and best methods of controlling the disease, will be continued this year.

PRUNING APPLE TREES.

The experiment on pruning young apple trees is being continued. This work has not progressed far enough to warrant any conclusions.

PUBLICATIONS.

During the year this Division has published Bulletin 209, entitled, "Self-sterility of the Scuppernong and Other Muscadine Grapes," and has recently submitted a report on "Double Blossom of the Dewberry and Blackberry."

Thanking you for the interest you have shown in our work, I beg to remain, Respectfully yours,

F. C. Reimer,
Horticulturist.

REPORT OF DIVISION OF ANIMAL HUSBANDRY.

I beg to submit the following report of the Animal Husbandry Division for the fiscal year ending June 30, 1911:

The major line of work of the Division for the past year has been a continuation of the investigations relating to the toxicity of cottonseed meal in swine. Guinea pigs and rabbits have been used largely during the last year to determine the promising lines of work. These experiments are then duplicated on large hogs as far as possible.

A study of the effect of Sea Island cotton seed and Sea Island cottonseed meal has been under way most of the year. From all indications the Sea Island cottonseed meal is equally as toxic as the Upland meal. A decision has not been reached regarding the toxicity of Sea Island seed. In this work two calves have been fed cottonseed meal for the purpose of determining the difference in the effect of the meal on calves and swine.

The experiment on feeding cottonseed meal to horses and mules has been completed, and the results have been reported in Bulletin 215. Also a general bulletin has been issued giving some practical information concerning the use of cottonseed meal for work stock. It also contains a brief report of the work done on this subject by other Stations, and some data from practical farmers who have used this meal extensively. The important conclusions drawn from the experiments at this Station are as follows:

Cottonseed meal may be used in limited quantities in the rations for work stock with satisfactory results, although in some cases animals will refuse it even after repeated attempts to feed it.

It should never be undertaken to feed cottonseed meal alone. It is a very concentrated feed and for this reason it should be used only as a supplement to carbonaceous feeds, such as corn.

The meal should always be fed with some finely divided concentrate. such as corn-and-cob meal, wheat bran or brewers' grains. The more thorough the mixture of cottonseed meal with the basal feed the more satisfactory the results will be.

The amount of cottonseed meal fed daily should rarely exceed two pounds per animal. A safe guide to follow will be to feed one-fifth of a pound of the meal per hundred pounds of live weight. Draft stock materially exceeding one thousand pounds in weight may use two and one-half and possibly three pounds per day in exceptional cases.

Based on the ration for a work animal of average weight, the amount of cottonseed meal fed should not exceed fifteen per cent of the total ration by weight. As a general thing the results will be more satisfactory if only ten to twelve per cent of the ration is composed of this meal.

The results obtained by the writer during three years experimental work show that no ill-effects will arise from the use of cottonseed meal if it is used with judgment, however, if it is unduly increased it will not only be refused but will injure the condition and working capacity of the animals.

The chief thing in mixing a cottonseed meal ration is to use the meal in connection with feeds which can be thoroughly incorporated with it, thus avoiding any quantity of the meal sifting through the ration to the bottom of the feed trough. Wheat bran is excellent for this purpose, although its use increases the cost of the ration.

Only bright, fresh colored cottonseed meal should be used. Meal which is dark yellow in color is likely old and somewhat musty. This stale condition of the meal no doubt at times is responsible for animals refusing it.

Cottonseed meal is an excellent laxative and for this reason it is desirable to feed with corn, aside from the fact that it furnishes the deficiency of protein in this feed.

The effect of cottonseed meal on the coat of the animal is to make it smooth and glossy, having the same effect in this respect as linseed meal.

The present price of cottonseed meal, which will average about $30.00 per ton, precludes any reduction in the cost of the ration. Its principal value must be derived from the beneficial effect on the coat, condition, and digestive system of the animal and in the enhanced value of the manure resulting from its use.

The experiments on feeding cottonseed meal, corn silage, corn stover, and cottonseed hulls to beef cattle will be reported in Bulletin 218. The chief objects of this experiment were to determine the difference in value of the three roughage feeds, namely: corn stover, corn silage, and cottonseed hulls.

Cottonseed hulls gave the largest gains both years, but the dressing percentage of the cattle fed this roughage was lower than either of the other lots the last year of the experiment. The cattle were valued as follows when finished for market: Lot 1, fed corn stover and corn silage, $5.90 per hundred; lot 2, fed corn silage, $6.00 per hundred, and lot 3, fed cottonseed hulls, $5.72½ per hundred. The first year the cattle fed corn silage made the cheapest gains, those fed cottonseed hulls the second cheapest gains, and the cattle fed corn silage and corn stover the costliest gains. The second year the cattle fed cottonseed hulls made the cheapest gains, those fed corn silage the second cheapest gains, and the cattle fed corn stover and corn silage the costliest gains, the same as the first year. With the two former roughages the results were reversed the first and second year. The indications are that the farmer should save a portion of his corn crop in the form of silage, and discontinue buying cottonseed hulls, which are becoming more expensive each year.

In conjunction with the publication of these experimental results a general bulletin will be issued on the Feeding and Management of Beef Cattle.

The writer contemplates some further work along the line of feeding cottonseed meal to beef cattle. The work planned includes the following:

(1) A determination of the most profitable amount of cottonseed meal to feed under Southern conditions; (2) a determination of the value of corn silage in prolonging the period of feeding and increasing

the amount of cottonseed meal which can be fed; (3) the influence of these various feeds on the quality and selling price of the carcass, and (4) the influence of the size and weight of animal on the total amount of cottonseed meal which can be fed, and the amount which can be fed per hundred pounds live weight.

During the last year six pure-bred Berkshires were added to the Station herd. A start has been made in Shropshire sheep, which will be used in the formation of a breeding herd for experimental work.

A considerable number of improvements have been made in the Animal Husbandry Division, which will aid in the efficiency of the experimental work.

Forage crops for swine are being grown continuously to determine the crops best adapted to the State for swine production.

The crops which are most promising are rye, rape, oats, Canada field peas, cowpeas, peanuts, and sweet potatoes.

Considerable correspondence comes to the office relating to the adaptability of the State for stock growing, and the feeding, care and management of live stock.

Respectfully submitted,

R. S. CURTIS,
Animal Husbandman.

REPORT OF DIVISION OF DAIRY HUSBANDRY.

I beg to submit the following report of the work of the Dairy Division of the Station for the year ended June 30, 1911:

The experimental work during the past year has been confined to cottonseed meal as a suitable feed for calves and growing heifers.

In the first experiment twelve heifer calves ranging in age from five to ten months were selected and divided into two lots or six each. Each lot received the same amount of corn silage and hay. For a grain ration lot 1 was fed a mixture of corn, oats, and wheat bran in equal parts by weight. Lot 2 was fed a mixture of cottonseed meal, oats, and wheat bran. The results showed that four of the six calves in lot 2, all four of which were under ten months of age, either made no gain at all or lost considerable during the first two months of the feeding. In addition they appeared very unthrifty. The two calves in lot 2 that were ten months old made satisfactory gains and growth, as did all of the calves in lot 1. At the end of two months all four of the young unthrifty calves in lot 2 were transferred to the grain ration of corn meal, oats and wheat bran, and at once began to improve, so that they made reasonably good gains from that time on. The results seem conclusive that cottonseed meal should not be fed to calves under ten months of age.

Another young bull calf was fed cottonseed meal mixed with skimmilk, four ounces of the meal per day being supplied at the start, with the amount gradually increased as the calf became older, so that he was receiving one and one-half pounds per day when he died after being on feed seventy-one days.

From the results secured it seems evident that cottonseed meal should not be fed to calves under any consideration before they are at least ten months old.

A Bulletin on the feeding and management of the dairy herd was published during the year.

Respectfully submitted,

John C. McNutt,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

I beg to submit herewith a report of the work conducted for the Entomological Division for the year ended with June 30, 1911:

During the summer and fall of 1910 most of my Station time was devoted to a study of the life history and habits of the two melon worms, *Diaphania nitidalis* and *Diaphania hyalinata,* this being the same project to which considerable time was given in 1909. Most of this investigation was conducted at West Raleigh. This consisted mainly in securing a large number of records of the development of the worms from egg to adult stage, the duration of the egg, larva and adult stages, breeding of parasites and predaceous insects, determination of the general habits of the larvæ and adults, egg-laying, etc. Field observations were also made at frequent intervals. Two trips were made in July, 1910, to the cantaloupe section of Robeson and Scotland counties. A full report of this investigation has been written and published as Experiment Station Bulletin 214. The bulletin contains technical descriptions of eggs and worms in all stages of development and description of the adult stages, as well as records of the breeding experiments which served to demonstrate the length of the life cycle for both species and the usual number of generations each year. The report shows that this pest is one which can be avoided by getting an early maturing crop of cantaloupes, for it was learned that the worms of the first and second generations, which mature during June and July, are not sufficiently numerous to cause noticeable injury, and the third generation, when the worms become destructive, does not develop until after about July 15. when an early cantaloupe crop should be largely matured.

The melon worm, *Diaphania hyalinata,* proved to be of little importance, compared with the other species. It appears later and seems to prefer to feed on the foliage, especially of summer squash when that plant is available. The report also indicates that parasites and natural causes are evidently keeping the melon worm down to small numbers.

An important result of the investigation was the determination of the value of summer squash plants as a trap for the pickle worm, *Diaphania nitidalis,* which is the species which the cantaloupe grower has to fear. The report shows that where summer squash plants were distributed through the cantaloupe fields that these served to attract nearly all the worms until about the first of August. The efficiency of this trap plant was fully demonstrated; one illustration of the benefit derived, as stated in Bulletin 214, is sufficient to prove this statement:

On July 27, 1910, in a four-acre field of cantaloupes, about 400 hills of summer squash were present, and when examined, proved to contain an average of 65 worms to each hill, while the maturing cantaloupes on all sides were practically free from worms. In fact, only one cantaloupe showed worm injury. However, at that date the summer squash were getting in very bad condition, practically ruined by worms, and as no late plantings had been provided their efficiency as a trap plant did not continue. Two weeks later the cantaloupes showed about ten per cent injured by worms. In ordinarily early seasons the cantaloupes around Raleigh are all gathered by August 1, hence the summer squash as a trap may be used successfully. Other fields of cantaloupes not protected by summer squash showed as high as 75 per cent destroyed by worms on August 1, when the field above mentioned had sustained practically no injury.

The investigation proved conclusively that cantaloupe growers should depend mainly on getting an early crop, or they should provide successive plantings of summer squash to attract the egg-laying moths, if their crop is to mature later than July 15.

Parasites and predaceous insects were found to be of some help in suppressing the melon worms, but they can not be expected to be numerous until late in the season, and their real value lies in destroying many worms that would otherwise live during the winter.

The melon worm project was not taken up again in 1911, because of a new project, the Corn Bill Bugs, which has required all of the writer's time and attention.

The detailed report of the Corn Bill Bug investigation up to July 1, 1911, is submitted herewith as a special article. This report shows that careful life history studies of the bill bugs have been started, but no records are yet complete.

MISCELLANEOUS WORK AND RECORDS.

In addition to the work on Adams Projects the writer has attempted to make observations and notes on all the injurious insects brought to his attention. During the past year there have been no serious outbreaks of insect injury except as recorded below. Some specimens of injurious insects, and a few common insects collected from one source or another, have been added to the insect collection. Notes concerning the occurrence of some insects of general interest have also been recorded.

The Spring Grain Aphis, *Toxoptera graminum,* has been unusually numerous and injurious in the oat and wheat fields on both the Station and College farms this past spring. Some fields were destroyed so that they were not harvested. This aphis injury appears to have been general over the State, and is largely accounted for by the weather conditions, a cool, damp spring, which always favors an increase of the aphids. When settled dry hot weather commenced, the natural parasites and predaceous lady beetles became numerous and destroyed most of the aphis, but not until after great damage had been done. 2

Corn Flea Beetles of two species, *Chætocnema parcepunctata* and *C. pulicaria,* were very abundant, and were destructive to young corn during May and June. One six-acre field on the College farm was injured so severely as to require replanting, and the writer noticed the beetles in great numbers in practically all the corn fields in this vicinity. Reports of their presence in other localities were also received.

Red Spiders, *Tetranychus gloveri,* have recently appeared in remarkable numbers in gardens in this locality and many reports have been received of their presence on cotton. This pest—not a true insect—is favored by continued hot dry weather, such as has prevailed during June, 1911. In gardens where running water is available, frequent drenching of plants serves to keep this pest in control. In cotton fields, or where water can not be used, a spray of one pound of laundry soap in four gallons of water is effective. The concentrated, commercial, lime-sulphur solution diluted one part to one hundred parts of water is an effective spray, and ordinary flour of sulphur, one ounce in one gallon of water will kill a large per cent of the red spiders.

The most important work of the year, except the Adams projects—melon worms and corn bill bugs—was that undertaken to suppress the *house fly, Musca domestica,* which was unusually abundant and troublesome during May and June. Attention was first directed to this problem on May 22, when Director Williams sent out a circular letter to the residents of West Raleigh, asking their coöperation in an attempt to make this township a sanitary district. Reports of typhoid fever and the undoubted presence of many flies, were responsible for this action. At Mr. Williams' request the writer commenced an investigation to determine the principal breeding places of the flies, and later, as recorded elsewhere, a method of poisoning flies with formaldehyde was successfully demonstrated. Newspaper articles concerning flies were written and appeared prominently in the Sunday editions of the Raleigh *News and Observer* and in the *Raleigh Daily Times.* On this date, June 30. the people of Raleigh and West Raleigh have cleaned up many breeding places by using formalin as a fly poison, and already the good results of the campaign are being spoken of. The flies around the College dairy and horse barns have been reduced to very small numbers by the combined work of removing the stable manure each week or oftener, and by poisoning thousands of flies with the formaldehyde. A report of the work with houseflies, up to the present date (the work is still in progress) is submitted herewith as a special article.

BULLETINS AND NEWSPAPER ARTICLES.

The following have been written by the Entomologist during the year:

Bulletin 214, "Two Important Cantaloupe Pests." This bulletin records the work of two seasons with the two melon worms spoken of in the report.

Circular Bulletin 23, "How to Suppress Houseflies." This circular was sent to all the newspapers in the State, with request for early publication.

For newspapers the following articles have been supplied: "Facts Concerning the Housefly," "Where Do Houseflies Breed?" and "The Housefly Must Go."

Other short articles were written and appeared in the daily papers concerning the success of the formalin poison treatment for killing houseflies.

Two articles, namely "Formalin Poison for Houseflies" and "Breeding Places of the Housefly" were written for the State Board of Health for publication in their monthly bulletin for July.

CORRESPONDENCE.

Letters received and answered have increased in number since my last report. Some of these letters have required very long replies because of having no bulletins on the subject that would answer. Letters concerning household insects such as ants, roaches, fleas, etc., and others relative to insects not usually discussed in bulletins, have increased the correspondence noticeably.

ENTOMOLOGICAL LITERATURE.

Additions to the entomological library have been made largely by bulletins. The Journal of Economic Entomology, the official organ of the Association of Economic Entomologists, has been secured in complete form to date. It is desirable to make additions in the form of complete files of older entomological publications, which can only be secured by purchase.

Respectfully,

R. I. Smith,
Entomologist.

REPORT OF DIVISION OF VETERINARY SCIENCE.

I beg to submit herewith a report of the work of the Veterinary Division for the fiscal year ending June 30, 1911:

In coöperation with the Animal Husbandry, Chemical and Animal Pathology Divisions work upon the study of the injurious effects of cottonseed meal feeding has been continued.

Clinical observations have been made upon 26 hogs fed treated and untreated cottonseed meal and upon one calf fed 1 per cent to 2 per cent of its body weight of cottonseed meal daily.

Necropsies were held upon 18 guinea pigs, 40 rabbits, and 3 hogs. dead from cottonseed meal feeding. Sections of various internal organs were saved and turned over to the Animal Pathology Division for histological examination.

Some blood examinations were made to determine any alteration in total solids, in amount of hemoglobin and in the differential count of leucocytes.

Numerous enquiries relative to diseases of livestock were answered. A much larger number of enquiries than heretofore were concerning the serum vaccination against hog cholera. These were referred to the State Department of Agriculture, which Department is producing the serum.

Twenty-four head of the Experiment Station hogs were injected with the serum April 18, 1911, when cholera made its appearance in the neighborhood and some 40 head of hogs were lost by one person. No signs of the trouble has as yet appeared in our herd.

A number of specimens of damaged feed, of animal parasites, and of diseased tissues were received for examination.

Respectfully submitted,

G. A. Roberts,
Veterinarian.

REPORT OF DIVISION ANIMAL PATHOLOGY.

I beg to submit the following report of the Animal Pathology Division for the period between September 1, 1910, and June 30, 1911:

The work has been confined to the cottonseed meal project in conjunction with the Chemical, Animal Husbandry, and Veterinary Divisions. A large number of small experimental animals have been fed with the various extracts, fractions, etc., prepared by the Chemical Division, both forced and natural feeding being used. It was the intention to make a thorough and detailed study of the postmortem and pathological lesions found but owing to the unsatisfactory conditions attending the unsanitary quarters and equipment for the animal room this plan had to be temporarily abandoned. The same state of affairs caused the postponement of the experiments as to the possibility of immunizing small animals against the cottonseed meal poisoning; study of the conditions of the blood in cottonseed meal poisoning, etc.

More satisfactory quarters and equipment for the animal room have been obtained and the above lines of work are now in progress with every indication of obtaining satisfactory results.

A small amount of time was used during the year in a study of fowl cholera. Besides assisting in repressive measures some sixty-odd autopsies were made, symptoms and lesions noted, and the causative organism studied to some extent.

WORK CONTEMPLATED.

The cottonseed meal project will continue to occupy the major part of the time of the Pathologist. The experiments already under way and those to follow as the work progresses will be coöperative work with the other Divisions working on this project. The particular field of this Division will be the supervision and care of the animal room and animal feeding observations, autopsy and pathological study of the smaller experimental animals and the planning and execution of the experiments on this project from the pathological and physiological side.

It is hoped that opportunity and facilities will be granted for work on vaccination against fowl cholera.

The usefulness of this and of the Veterinary Division would be enlarged were it possible to undertake the diagnosis in the laboratory of the cases brought to the attention of the Veterinarian, most of which are either too indefinite or of a character which renders it impossible to make a diagnosis through the brief description of the symptoms contained in a letter.

The research work of this Division would be more valuable were it possible to coöperate with the State Veterinarian in the study of the infectious diseases which he encounters in his frequent visits to different parts of the State. In the absence of a State Veterinary Laboratory, the Animal Pathology Division of the Station seems to be the logical place to undertake this work, and it is hoped that something along this line may be undertaken in the near future.

Respectfully submitted,

Jos. D. Cecil,
Animal Pathologist.

RECEIPTS AND EXPENSES.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1910-1911.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1911, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	15,000.00

CR.

	Hatch Fund.	*Adams Fund.*
By salaries	$6,186.94	$10,656.98
Labor	2,588.75	1,129.28
Postage and stationery	266.57	183.22
Freight and express	188.37	108.22
Heat, light and water	295.70	37.20
Chemical supplies	42.70	466.21
Seeds, plants and sundry supplies	573.84	113.49
Fertilizers	892.27	439.44
Feeding stuffs	1,689.21	329.56
Library	134.13	206.10
Tools, implements and machinery	679.39	341.81
Furniture and fixtures	137.22	51.93
Scientific apparatus	4.55	283.15
Live stock	609.65	275.75
Traveling expenses	408.49	288.24
Contingent	29.00	....
Buildings and land	273.22	89.42
Total	$15,000.00	$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1911; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $30,000, and the corresponding disbursements $30,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed) W. E. DANIEL,
JNO. O. ELLINGTON,
O. MAX GARDNER.
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

SCIENTIFIC PAPERS

DOUBLE BLOSSOM OF THE DEWBERRY AND THE BLACKBERRY.[1]

F. C. REIMER AND L. R. DETJEN.

Ever since dewberries and blackberries have been grown in America on a commercial scale the marketable crops of certain varieties have been considerably reduced by a serious disease commonly known as Double Blossom. Usually one or two good crops of berries are gathered and then the trouble begins. The berry patch becomes more and more infested and rapidly declines in productiveness until soon the whole field becomes unprofitable.

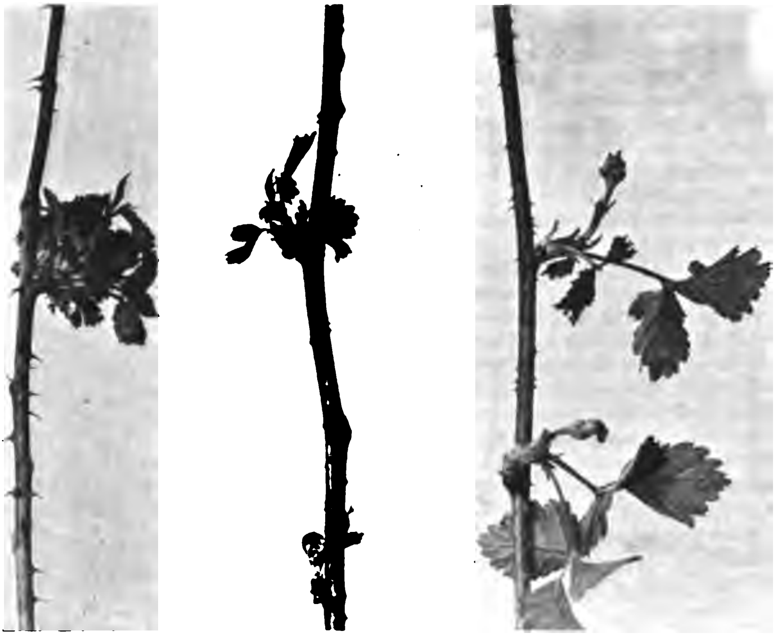


FIG. 1.—Early stage of the "witches broom" on Lucretia dewberry. The two canes on the left show the broom formation; while the one on the right shows the normal growth.

The consensus of opinion among fruit growers generally is that spraying with fungicides has no effect on the spread of this disease. This leads some to believe that the double blossom is not caused by a microörganism, but that it is a peculiar physiological condition of the leaf and flower buds.

---

[1] Specimens of this fungus were sent to Dr. M. T. Cook of the Delaware Station, who identified it as Fusarium rubi, Winter.

To determine the cause of the trouble an experiment was planned and begun in the spring of 1908. Because of the two views prevalent as to the cause of the double blossom two lines of investigation were followed. viz.: physiological and the pathological.

PHYSIOLOGICAL INVESTIGATION.

The physiological investigation was conducted principally along four lines, to determine—

(1) Whether the double blossom is caused by severe pruning.

(2) Whether the witches broom is the result of a luxuriant outgrowth from frost-bitten branchlets.

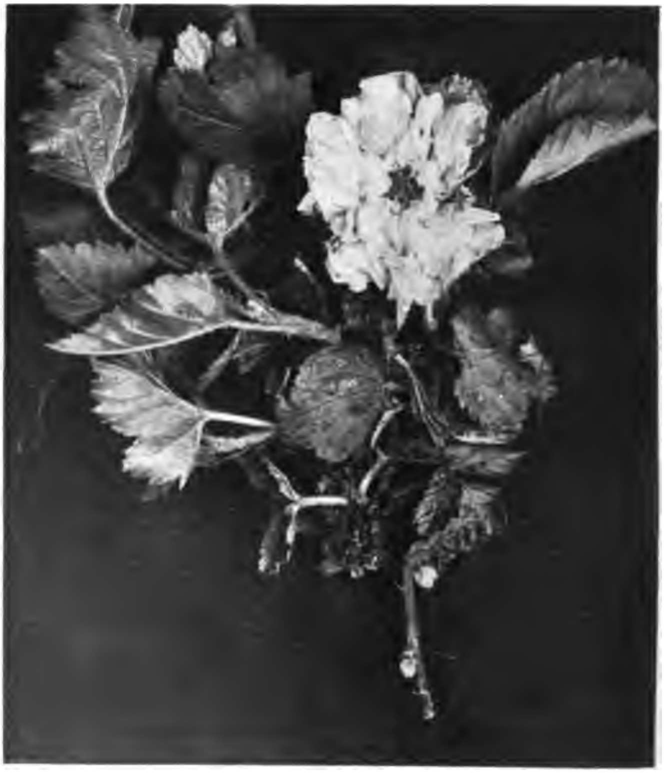


FIG. 2.—Double blossom on the Wilson blackberry.

(3) Whether the witches brooms and the sterile blossoms are the result of immature and imperfect scale-buds.

(4) Whether insects, especially aphids, are indirectly the cause of the brooms.

EFFECT OF PRUNING ON DOUBLE BLOSSOM.

In the spring of 1909 a field of Wilson blackberries was laid off into six plats of three rows each. When the young shoots were sufficiently high the canes on each of the plats were pruned down to 12, 18, 24, 30, and 36 inches respectively, and the sixth plat was left unpruned as a check.

No rosettes or brooms developed in either of the plats. Pruning then gave us only negative results.

EFFECT OF COLD ON DOUBLE BLOSSOM.

If the witches broom is the result of a luxuriant outgrowth from frost-bitten branchlets then it could be easily produced artificially.

It was frequently noticed that whenever a leaf dropped prematurely, either from disease or otherwise, the axillary bud would begin growth. The resulting immature shoot, being tender and exposed to the elements of winter, was frequently killed back nearly to the cane whence it sprung. The tip being killed, new growth would push out from the basal or scale-buds of the injured member and since severe winter pruning induces wood growth the result would be a witches broom.

To investigate we clipped off on June 21, 1909, one whole crop of leaves from every third row of the Wilson blackberry patch, and on July 19 a second crop, with the exception of that from the first row. No witches brooms were formed on any of the rows as a result of this kind of treatment.

To determine whether frost is the cause of the formation of the witches broom young canes from badly infected patches were transferred to the greenhouse.

The transplanting occurred in October, some time before frost. These canes, however, developed brooms just as freely as those left out of doors in the affected patch. This seems to establish the fact that frost plays no part in the development of double blossom of the berry canes.

THE RELATION OF SCALE-BUDS TO DOUBLE BLOSSOMS.

Another theory advanced was that the scale-buds did not have time to mature and properly develop perfect flower buds: hence their sterility; and that the witches broom is an abnormal growth resulting from the forcing immature scale-buds.

To investigate this theory we selected on October 4, 1909, two lots of buds. One lot, consisting of 351 buds, was treated by removing only the apical portion of the primary bud, thus leaving the secondary and scale buds unharmed. Of these 351 buds 119 developed shoots and only 21 developed fruit. Of these 21 shoots 15 developed from secondary and 6 from scale-buds.

The results seem to indicate that shoots arising from secondary and scale-buds, when flowers are produced, will, all other conditions being favorable, develop well formed fruit.

The number of branches to the brooms ranged from 1 to 3. Of the 119 growing buds 97 produced one branch, 14 produced two branches, and 8 three branches.

In most of the cases the secondary only developed in place of the primary bud. Sometimes the secondary and one or two scale-buds developed. While most of the shoots were flowerless like those of the witches broom, yet not one developed any abnormal flower.

Since in the treatment outlined above the secondary bud usually takes the place of the injured primary, and since the secondary bud is better developed than any scale-bud, a second lot consisting of 267 buds was selected on the same date, in which the apical portion of both the primary and the secondary buds was removed. This operation throws all the growth into the production of adventitious branches.

The results of this work are as follows: Of the 267 buds that were treated only 43 put forth branches. Of these 33 produced one branch, 7 two, 2 three, and 1 four branches.

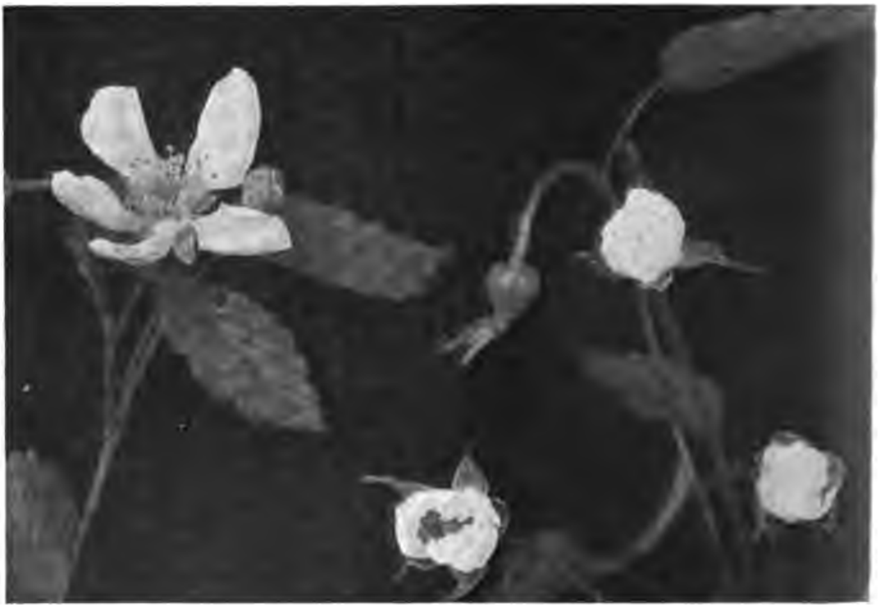


FIG. 3.—Lucretia dewberry canes showing affected flowers and bud on the right, and a normal flower and bud on the left.

Of the 43 branches that leafed out only three bore fruit, each bearing one berry to the cluster; three had normal flowers, and the rest produced only sterile branches.

The size of the brooms was, as noted above, from one to four branches—not at all characteristic of the double blossom.

RELATION OF APHIDS TO DOUBLE BLOSSOM.

It was noticed that whenever a sufficient number of aphids attack the young growth of blackberries an abnormal swelling of the cane results. An equally deformed fruit panicle may result whenever the attack is directed to a leaf bud.

To determine their influence three canes that were covered with green aphids and were already deformed on the extremities were transferred from the field to the greenhouse.

These canes developed normal leaves and branches, with the exception of one, which produced a witches broom. This broom, however, was not the result of the work of aphids, but as will be seen later, the natural outcome of having stood in the field in too close proximity with diseased canes.

The fact that the other two canes did not produce any apparent symptoms of the disease is good evidence that aphids do not cause the double blossom of the berry canes.

PATHOLOGICAL INVESTIGATION.

All the above work has given us only negative evidence on the disease question and brought us little or no nearer to the solution of the problem. Therefore, the pathological side of the question contained the only possible solution to the problem within the scope of the investigation.

Looking at the problem from this view point the work naturally falls into four lines of procedure.

1. To determine whether the double blossom is infectious.
2. The finding of the parasitic organism and its isolation in pure culture.
3. Inoculation of plants and production of the characteristic symptoms of the disease.
4. The re-isolation of the organism from the artificially inoculated plants.

To determine whether the double blossom is infectious and whether the disease spreads from the old to the young canes three blackberry (*R. nigrobaccus*) and six dewberry plants (*R. villosus*) were grown from root cuttings of wild plants.

On March 14, 1910, two of these blackberry plants and four dewberry plants were set, without removing the flower pots, among diseased canes of wild blackberries. Here the plants were left for the remainder of the summer.

The remaining blackberry plant and the two dewberry plants were set out as check plants, not among diseased but among healthy canes, and left there for the remainder of the year.

On February 2, 1911, all plants were gathered up and set in the greenhouse for developments.

The two blackberry plants that had been standing among diseased canes showed, on March 17, one diseased leaf bud on one plant and two on the other.

Of the four dewberry plants similarly treated one died before putting forth its leaves, two produced one broom apiece, and the fourth produced eleven distinguishable witches brooms:

The check plants, both blackberries and dewberries, are perfectly healthy and show no symptoms of disease.

This is strong evidence that the disease commonly known as double blossom is transmitted from the old to the young canes. Our second step was to find in the diseased buds a parasitic organism that can be isolated in pure culture.

Numerous buds of apparently healthy canes that stood in the diseased clumps were examined under the microscope. A fungus was detected, isolated, and grown in pure culture.

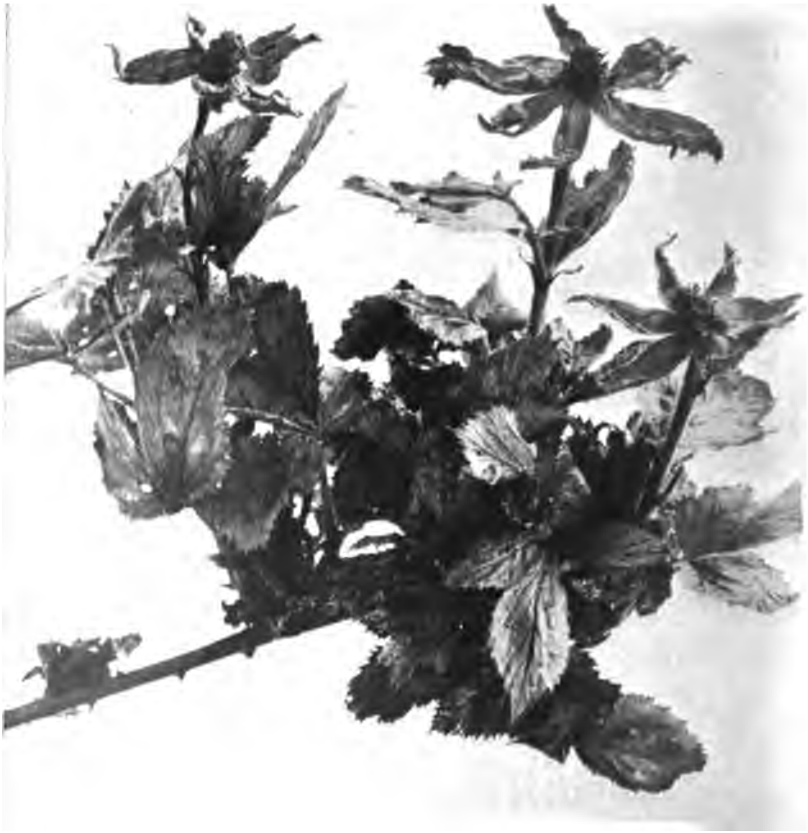


FIG. 4.—Witches broom and empty calyses of Wilson blackberry flowers.

The media used, on which to grow the fungus, were ten per cent and thirty per cent saccharose solutions, blackberry leaves, and blackberry leaf agar.

The vegetable growth was most luxuriant in the saccharose solutions and on the agar, and the least on the blackberry leaves, however, the fungus produced spores earlier on the leaves, while in the solutions and on the agar little or no spore production was observed.

The next step was to make inoculations on blackberries and dewberries that would cause the disease.

Root cuttings of the wild high bush blackberry (*R. nigrobaccus*) were made from which to grow perfectly healthy plants. Also tip layers of the Lucretia dewberry were selected and all transferred in January, 1910, to the greenhouse, so as to avoid possible infection by wind and insects.

In all 25 dewberry plants were selected for the test, 23 for inoculation and two for check plants. Of the blackberry plants 35 were selected for the experiment, 32 for the inoculation and 3 for check plants.

On February 19, 1910, when the plantlets had attained a height of six inches, the first inoculations were made, both on blackberries and dewberries. These were made by dropping onto the axillary leaf-buds a suspension of spores of the fungus in tap water. Similar inoculations were made on February 28, March 4, 11, 16, 23, and 27.

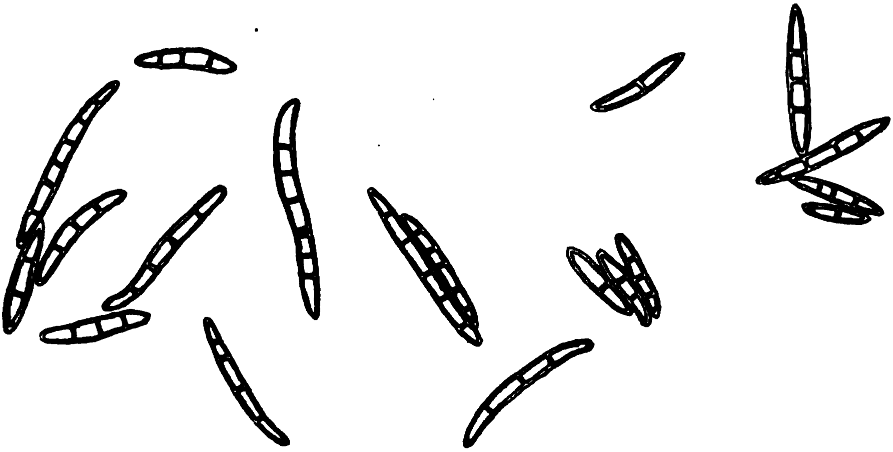


FIG. 5.—Spores of Fusarium, rubi, Winter.

On March 28 dry spores and mycelium were introduced into all of the available leaf buds of the plants with the aid of the blunt point of a needle.

On April 2 and 7 a suspension of spores was again dropped onto all available buds of both lots of plants. On April 13 the larger buds were again pricked with a blunt needle, but instead of dry spores being introduced a suspension of spores was simply dropped onto all injured buds.

On April 20 and 29, on May 7, 14, 20, and 28, and also on June 11 and 23, spores in suspension were dropped over the uninjured and previously injured buds.

On June 29, July 5 and 28, and August 5, small colonies grown in saccharose solutions and fragments of mycelium of the fungus suspended in water were dropped onto the later formed leaf buds.

The two dewberry plants and the three blackberry plants reserved as check plants were kept in another part of the greenhouse, so as not to become infected from the liberated spores.

The inoculated plants were kept in a cool room of the house and by November 30 they had grown to a length of 18 feet.

On January 3, 1911, the bottom leaf buds on the canes of both dewberries and blackberries began to swell. These later on proved to be typical cases of the double blossom.

The check plants did not begin growth until about February 11, 1911. and on March 21 they did not show a sign of the double blossom disease. although the infected flower buds on the inoculated canes were blooming profusely.

Of the 23 inoculated dewberry plants 22 produced witches brooms and only one did not develop the disease.

On March 17, 1911, these 23 dewberry canes showed a total of 90 witches brooms. The check plants produced no brooms and developed no symptoms of the disease.

Of the 32 inoculated blackberry canes 16 died down to the ground after the spore inoculation, but new canes sprung forth before the treatment with the mycelium. These 16 new canes produced only one witches broom.

The other 16 plants did not put forth any new growth, but have remained alive up to the present writing. Of this lot 11 out of 16 plants showed the diseased buds and five had no apparent symptoms.

These 11 affected canes showed on March 17, 1911, a total of 78 characteristic witches brooms.

On November 15 and December 5, 1910; also on January 30, 1911, a total of 157 dewberry buds and 139 blackberry buds were inoculated with mycelium from the saccharose solutions and the blackberry agar.

Of the 157 dewberry buds only seven showed the symptoms of the disease and the balance remained apparently unaffected.

Of the 139 blackberry buds only one showed the diseased condition and the balance were apparently healthy.

Evidently this last inoculated lot of buds was too far advanced for the fungus to get a secure foothold.

Fearing that the greenhouse conditions were not suitable for the development of the fungus, inoculations were made out of doors on April 30, 1910.

The spot selected is in a little grove of mixed deciduous trees. No traces of the witches brooms were to be found in the vicinity and the blackberry canes growing there were all vigorous.

On April 30, 1910, healthy canes were selected out of the midst of a clump for the purpose of inoculation. Spores were used to tranfer the fungus and each inoculated cane was carefully marked.

All of the adjacent canes were left as a check.

On March 17, 1911, observations showed that three of the ten canes had died during the winter, but the remaining seven were covered with miniature rosettes—79 in all.

The adjacent canes were carefully examined and buds were dissected under the microscope, but no trace of the fungus could be found.

The experiment corroborated the results that were obtained in the greenhouse.

In order to determine whether the witches brooms that were produced in these experiments were caused by the same parasitic fungus obtained from field specimens, the work of re-isolating the organism from the artificially produced witches brooms was begun. The fungus was easily extracted from the diseased buds and isolated in pure culture. This newly isolated fungus corresponds in all particulars with the original. It shows the same fish-net like growth of the mycelium in the leaf buds; the same peculiar crystals of salt that are always associated with the mycelium in the bud; the same method of spore production; the same shape, size, and hyaline color of the spores; the same greenish by-product when grown on artificial cultural media.

In every respect, so far as can be determined, this fungus is identical with the one always found in the diseased buds in the field.

SYMPTOMS OF THE DISEASE.

The double blossom disease is caused by a parasitic fungus that lives first in the leaf buds of the young canes, and as they develop it spreads over the entire resulting rosette. The worst damage results from the infestation of the floral organs, which means death to the embryonic berry.

In the early part of November the mycelium can be detected with the aid of a microscope in the affected buds of young canes. Upon dissection of the buds in January it comes out in flake-like particles, and these under the microscope have the appearance of torn and imperfect fish-nets. All through the winter months the fungus continues to develop inside of the bud until by the end of February all of the interstices between the embryonic leaves are completely filled.

As a rule on the outside of the bud no visible change occurs until the appearance of the warm days of spring, when the most affected buds begin to swell prematurely and push forth their leaves. These usually have a reddish color, which can be seen at some distance.

Instead of one normal shoot growing from the bud a great indefinite number may appear, which cluster, later, at maturity, is spoken of as the "witches broom."

When the buds are only partly affected so that the flower buds alone suffer, then these symptoms can not be detected by the naked eye, and later developments alone will manifest the disease.

If the infested leaf buds can be distinguished in the fall of the first year then the cutting out of the affected canes can be accomplished early, and thus curb the spread of the epidemic.

To determine whether this diagnosis can be made in the fall of the year, 160 lateral leaf buds that looked suspicious were labelled in 1909 and their development noted in the following season.

Observations showed that of the 160 buds so labelled not one developed the witches broom. However, it was noticed later that some of the very earliest and worst affected leaf buds do prematurely push forth a miniature broom in the fall of the first year, but these are only a very small percentage of the total number of buds so affected.

Instead of killing the young leaf bud from the start the fungus stimulates it to more vigorous growth, increasing thereby its food supply and causing the familiar cluster of branches commonly known as the witches broom.

These brooms may be large or small, depending upon the size and vigor of the parent plant. It is a peculiar but well-known fact that these brooms are formed primarily by the development of basal or scale-buds of the new shoot or shoots. Most of these resulting branches are sterile and will not put forth any flower buds. The normal fruit panicle, after having spent all of its energy in the production of woody and leaf tissue in the broom formation, is materially reduced in size and number of fruit buds. The flowers that develop both from the branches and from the terminal panicle of the broom are usually so infested with the fungus, and the floral organs are so distorted that no fruit development could possibly ensue.

TREATMENT OF THE DISEASE.

Our spraying experiments have not been conducted long enough to give conclusive results as to whether spraying will be practical in the treatment of this disease. The results so far indicate that spraying will not prove a practical remedy.

The best treatment that we can recommend for this disease in this State at the present time is to cut off all the dewberry canes (both young and old) at the surface of the ground as soon as the picking season is over. The canes should then be removed from the patch and burned. This treatment removes all the old diseased canes and any young canes that have become infected early in the season. Where this treatment is given every year the disease is kept under absolute control.

The treatment outlined above is now being given by nearly all of the growers in this State to control anthracnose and leaf spot. Hence the one treatment will control the three most serious diseases of the dewberry.

The varieties of blackberries most seriously affected by double blossom are now seldom planted in this State. We now have varieties of blackberries that so far have proved resistant to this disease which ought to replace the affected varieties entirely. Where the affected varieties are grown the best remedy will probably be to destroy the affected parts early in the spring before the blooming season.

PRELIMINARY REPORT OF INVESTIGATIONS WITH THE CORN BILL BUG.

PARTICULARLY WITH *Sphenophorus callosus.*

BY R. I. SMITH, ENTOMOLOGIST.

The corn bill bug, *Sphenophorus callosus,* was reported as doing unusual damage in the spring of 1910, in Camden and other of the coastal counties. This damage was reported to Director Williams with a request that the Station commence an investigation of this pest, which, the corn growers stated, was increasing in alarming numbers. To prepare for complying with this demand your Entomologist made a trip to Columbus and Robeson counties, where he found some very serious bill bug injury. On June 20, 1910, at Braswell, Columbus County, on a farm owned by F. T. Shepherd, a corn field was discovered at a time when the third planting of corn was being destroyed by the bill bugs, even though the latter were comparatively scarce, because of hundreds having been collected by hand during the previous two or three weeks. On this same trip bill bugs were discovered and collected at Chadbourn (in a rice field principally), and at three points in Robeson County, namely, Lumberton, Proctorville, and Elrod. At all these places the bill bugs were found to be laying eggs and breeding in the corn plats, a condition that was not previously known to exist in this State. Practically all previous reports state that the bill bugs breed entirely in rice and sedge grasses, but not in corn.

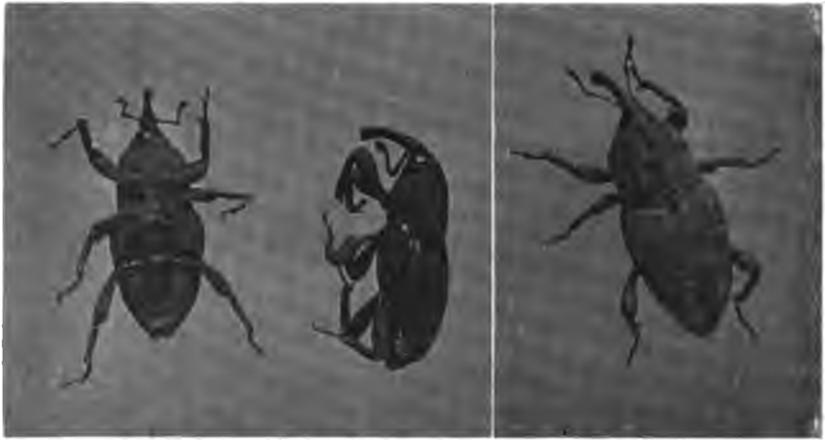


FIG. 6.—*S. callosus.* Adult Beetle stage of Corn Bill Bug: On left and middle, males, photograph of dead specimens; on right, live female standing on glass, in natural position, ready to walk. (Original.)

The bill bugs collected on this trip, from the points mentioned, were taken to West Raleigh and kept alive on green corn stalks in which they

Google

continued to lay eggs until after September 3, and probably later, but after that date they were given no further careful attention, except to be given occasional fresh food. Of this lot of beetles collected June 20, 1910, originally 17 in number, 16 were found alive on February 14, 1911, but on March 1 all were dead. During the winter the beetles were kept in a large glass jar half full of earth, in which they remained buried, except on warm days, when two or three were sometimes seen moving about on the surface. If these beetles had not been disturbed, as was necessary to determine their condition, some would doubtless have lived longer. This represents the first of the bill bug investigation.

On August 27, 1910, an outline of a proposed investigation of the injurious species of *Sphenophorus* occurring in North Carolina, but especially the principal injurious species, *Sphenophorus callosus,* was submitted and accepted as an Adams Fund project.

The preliminary report herewith given, records the general observations and study which was desirable before commencing a careful life history investigation of these insects, such as is now under way. The investigation will doubtless cover two or three years, as the writer can not take up all phases of the study in one season without assistance.

During the trip to Robeson and Columbus counties, about June 20, 1910, the young stages, that is, eggs, larvæ, and pupæ, were secured, and enough information obtained to enable the writer to search intelligently for this pest in other places. This resulted in his finding *Sphenophorus callosus* breeding in certain species of *Cyperus* grasses growing in corn fields at West Raleigh, and, later, in finding out other food plants, which are recorded below.

On July 28, 1910, bill bug eggs and larvæ were discovered in the stems and roots of Elegant Nutgrass, *Cyperus flavicomus,* in bottom land at West Raleigh. A few eggs, but no larvæ, were found in some young corn plants. During August and September many *Sphenophorus* larvæ, pupæ, and adults were collected from *Cyperus flavicomus* growing in corn fields about West Raleigh, all the specimens proving to be *S. callosus.*

On October 5-7, 1910, a trip was made to Lumberton, Chadbourn, Proctorville, and Pembroke, to collect bill bugs to keep during the winter for life history work this spring. It proved impossible to find more than one or two beetles in the corn fields where the eggs and larvæ were found in abundance during the June trip, but a rice field at Pembroke and another at Chadbourn yielded a number of beetles which were taken into the laboratory and kept in jars of earth during the winter. Pupæ, from which adult beetles were reared, were also taken on this trip. New food plants were also discovered.

FOOD PLANTS.

The food plants thus far ~~determined~~ are listed herewith. Eggs, larvæ, and in some instances pupæ, of *S. callosus,* have been taken from the roots, or beneath the roots, of the following plants. Breeding in corn at Braswell, Elrod, Chadbourn, Proctorville, St. Paul's, Pembroke, and Raleigh, June to October, 1910.

Breeding in *Cyperus flavicomus*, July and August, 1910, at Raleigh.
Breeding in *Cyperus strigosus*, October 4, 1910, at Lumberton.
Breeding in *Cyperus strigosus*, October 6, 1910, at Chadbourn.
Breeding in *Cyperus cylindricus*, October 4, 1910, at Proctorville.
Breeding in *Cyperus overlaris*, October 7, 1910, at Pembroke.
Breeding in Rice, October 5-7, 1910, at Chadbourn and Pembroke.
Breeding in *Cyperus esculentus*, June, July, 1911, at Raleigh.

It is probable that many other *Cyperus* grasses and probably some other closely related grasses will prove to be food plants.

WINTER STAGE.

Judging from the actions of the beetles confined during the past winter months in glass jars on several inches of earth, it seems that they normally lie buried from one to three or four inches deep, but sometimes become active during warm spells. This seems all the more certain because the writer has spent many hours searching for bill bugs this past winter, but has never found any of them under weeds, trash or materials where they would hide if they remained above ground.

On March 28, 1911, the writer went to Chadbourn, Columbus County, for the express purpose of trying to find corn bill bugs. A visit was made to a rice field where the insects were breeding freely last year, and several hours were spent in hunting for the bill bugs, in all possible situations. Everything under which they could hide, weeds, bush, stones, etc., were examined, but no beetles were found. After some two hours' search one bill bug was discovered in the dead grass on a mound of earth around a stump in the edge of the rice field. This beetle was alive and active, evidently having emerged from its winter shelter. Much rice stubble was also dug up and the roots searched for bill bugs, but with no success. A nutgrass field, *Cyperus strigosus,* near by, where bill bugs were breeding freely last October, was next examined, but no sign of the bill bugs, except evidence of their work in the roots, could be found. This search indicated that the beetles must be buried in the soil, unless they had deserted the field for parts unknown.

On March 30, at Braswell, a whole day was spent searching for bill bugs, but with no success. This was the place where corn of the third planting was destroyed in June, 1910.

On March 31 a rice field at Pembroke was visited and several hours were spent looking for bill bugs, both above and below ground. Not a single specimen was seen.

During the month of April last, several field trips were made around Raleigh, searching for bill bugs in places where they were breeding in *Cyperus* grasses last fall. The beetles were searched for in all manner of situations, under all kinds of protection, and in the soil under some dead *Cyperus* plants which were discovered. Several plants in which the *Sphenophorus* larvæ had fed, were discovered, but there was no sign of the insects.

The beetles that were kept all winter in jars of earth were examined at different dates, and, as already stated, one or two were seen moving about on warm days. The majority remained buried all the winter.

On April 13, when it seemed that some beetles should be emerging from winter quarters, two lots of beetles were taken into the laboratory from the outdoor cage, where they had been kept, and each lot examined.

Lot 1 contained 10 beetles that were bred from pupæ collected from *Cyperus flavicomus* near Raleigh, during September, 1910. Two dead beetles were found on top of the soil, the remaining eight were located in the soil at depths of one to two inches. Six of them, when dug out, were active; two were alive, but would not crawl about.

Lot 2 contained 20 beetles collected in the adult stage from beneath roots of *Cyperus flavicomus* about September 10, 1910. Of this lot nearly all were buried from one to three inches deep. Upon digging them all out on April 13, 17 were found alive; the other three were dead.

These two lots of beetles were placed back on loose earth and given young green corn plants for food. The notes recorded show that all but two or three of each lot immediately buried themselves in the soil and were not again disturbed until after April 26. The beetles of Lot 1 did not feed, but one or two of the beetles in Lot 2 fed a little every day after April 13. Evidently the majority remained buried.

Lot 3, consisting originally of 29 beetles, collected October 5-7, 1910, from fields at Braswell, Chadbourn, and Pembroke, were not disturbed after they buried themselves for the winter, until May 1, 1911. On that date the large tin can of earth in which they had passed the winter was taken into the laboratory and examined. The warm weather had brought 12 of these beetles to the surface, where some were moving about; the remainder were buried in the usual manner. Of the entire number 26 were found alive. These were placed in a glass jar with pieces of moist blotting paper and given fresh corn plants for food. On May 2 some had fed considerably, but none of them showed signs of mating.

FIRST BILL BUGS DISCOVERED IN FIELD.

On April 19 and 20, several hours each day were spent looking for bill bugs in fields near West Raleigh where *Cyperus* grasses grew last fall, and in fields where corn was just coming up. All possible hibernating quarters were also examined, but not a single bill bug discovered.

On May 2 another search was made with better success. After three hours search one beetle was taken on a young corn plant in an upland field in which considerably so-called nutgrass was springing up. This beetle proved to be *Sphenophorus venatus*. Unfortunately it lived only a few days.

In the field where this beetle was found the corn was only a few inches high, but several plants showed the characteristic holes, made by bill bug bites before the tender leaves were unfolded, showing that this specimen, and others, no doubt, had been feeding several days. Search was made for eggs, but none were found.

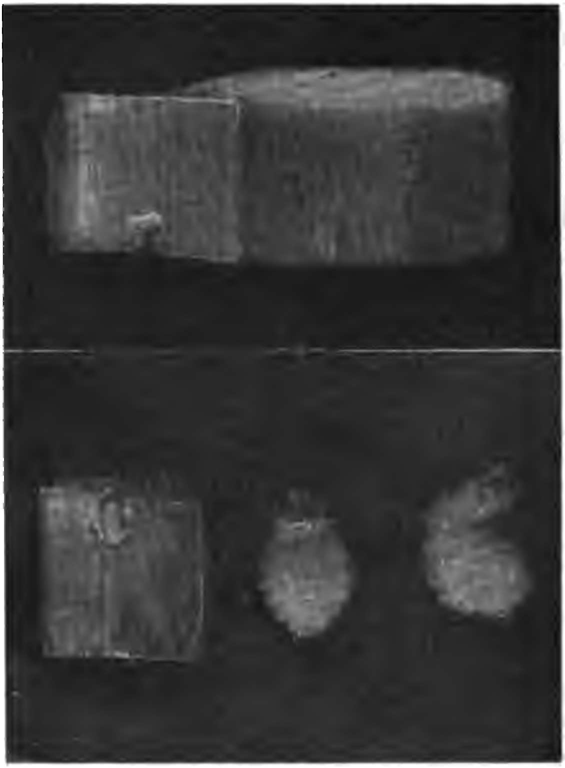


Fig. 7.—*S. callosus.* Corn Bill Bug Eggs and Larvæ: Upper figure shows short section of cornstalk as supplied beetles for food to secure daily egg-laying record; egg embedded in natural position in the tissue on inner side of the outer leaf. Lower figures show egg fully exposed; larvæ about two-thirds grown, ventral and side views. All enlarged 2½ times. (Original.)

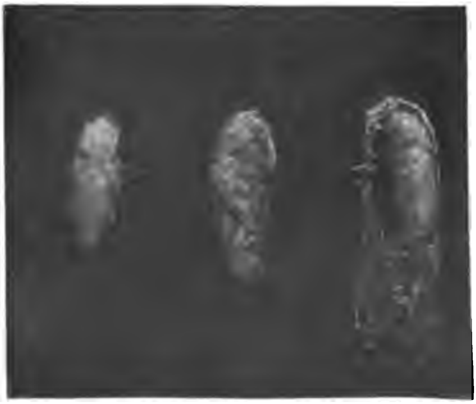


Fig. 8.—*S. callosus.* Pupæ and Cocoon Formed of Corn Fiber: Two small pupæ on left, upper and side views: on right, live pupa in its cocoon. (See Fig. 11, showing how this cocoon protected the pupæ.) All enlarged 2 times.

On May 9 the writer was at St. Pauls, in Robeson County, and discovered bill bugs, *Sphenophorus callosus,* in a corn field belonging to Mr. Marcus Smith. The corn had been replanted, and, according to Mr. Smith, most of the first planting had been killed by the bill bugs. About 75 per cent of the second planting was damaged. Bill bugs were not easily found, but after a search of one and one-half hours 15 beetles were collected. No sign of eggs could be found. These beetles were taken to the laboratory and fed on young corn plants and watched daily for signs of mating and egg-laying, but this was not noticed until after May 22, when another lot of beetles commenced to lay eggs.

On May 22 eggs were secured from a lot of over-wintered beetles collected at Braswell and Pembroke in October, 1910. As this date came on Monday and the specimens were not examined on Sunday, it may be that the eggs were laid as early as Saturday afternoon, May 20.

Previous to this date, that is on May 13, three bill bugs were taken in a field near Raleigh, but they died in a few days. No eggs were found on that date. On May 19 one female *Sphenophorus parvulus* was found on yellow nutgrass, *C. esculentus,* and as this beetle proved to be fertilized it has since been kept for a daily egg-laying record.

EARLIEST RECORD OF EGGS IN FIELD.

After finding eggs on May 22, laid by the beetles in confinement, the writer went at once to the corn-field where a bill bug had been collected May 2. This trip proved fruitful. Eggs were discovered in the so-called nutgrass, since identified as *Cyperus esculentus,* and considerable evidence of bill bug feeding was observed on both young corn and nutgrass plants.

That this date represents about the earliest for egg-laying in the field is evidenced by a letter from Mr. Marcus Smith, of St. Paul's, dated May 26, who stated that "beetles have commenced to lay eggs." (Mr. Smith had been on the outlook for egg-laying at my request.) As further evidence a letter from Mr. F. T. Shepherd, of Braswell, dated May 17, states that "bill bugs have not commenced to lay eggs."

EGG-LAYING RECORD COMMENCED.

After May 22 individual pairs of bill bugs were taken as rapidly as possible from the material on hand, and each pair isolated, with corn for food, in a jelly glass, to secure daily egg-laying records. On May 26 a batch of bill bugs, about 190 in number, were received from St. Paul's through the kindness of Mr. Marcus Smith, and from this lot most of the pairs for egg-laying were secured. For some reason not yet understood the beetles kept in confinement during the winter did not seem to lay eggs freely. Some of the pairs secured from that material failed to lay any eggs, while others laid only a few. At the same time some of the females secured from St. Paul's refused to lay. Several pairs were kept and fed for 30 days, from May 22 to 28 until July 5, and no eggs were secured. Others, kept for the same length of time, laid an occasional egg at long intervals. Complete records are on hand to be used for a full report of this work.

Over 50 mated pairs of bill bugs were taken, but at this date, July 1, only 24 pairs are being kept for a complete egg-laying record. From some of these pairs over 150 eggs have been secured since May 28, an average of about five eggs a day. The eggs were counted and fresh food given the beetles each day. The large number of pairs retained for a complete egg-laying record will serve to furnish a good average record of egg-laying.

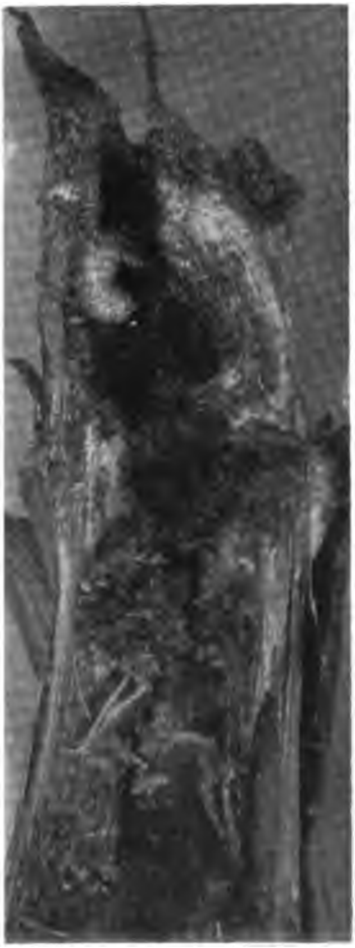


FIG. 9.—*S Callosus*. Corn Bill Bug Larva in Feeding Cavity in Corn Root. Larva reared from egg, twenty-eight days old, but small for age Enlarged 2 times. (Original.)

EGG-HATCHING RECORDS.

From the eggs secured, hundreds of hatching records have already been obtained, showing an incubation period of from about five to ten or eleven days, dependent on both moisture and temperature conditions.

FEEDING AND EGG-LAYING HABITS.

An accurate knowledge of the habits of the bill bugs as regards feeding and egg-laying is being learned by daily observations. The behavior of the confined beetles seems to be, in every respect, similar to that observed in the field.

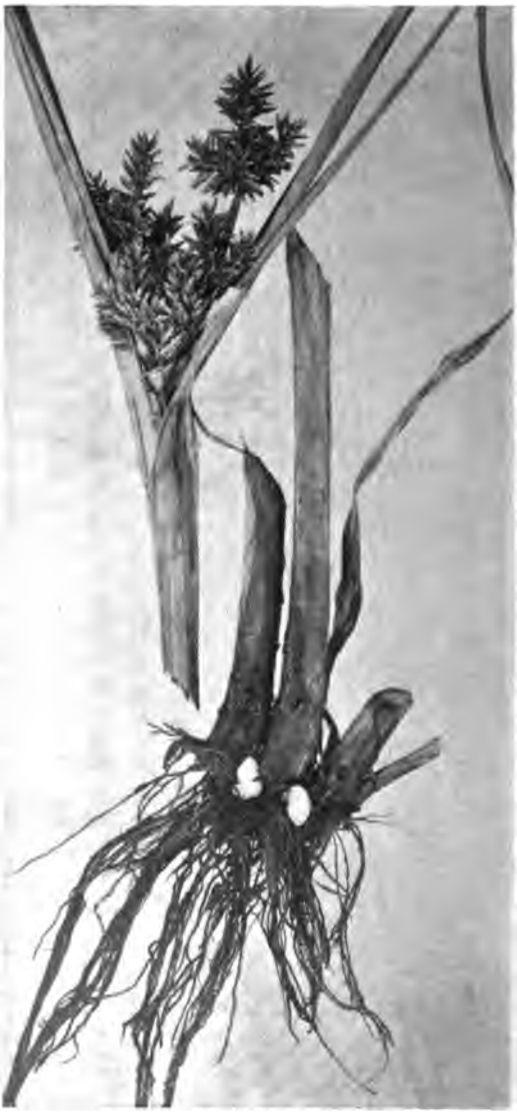


FIG. 10.—*S. callosus.* Corn Bill Bug Larvæ in Crown of Red Rooted Cyperus Grass (*C. flavicomus*). Collected from a corn field, September 9, 1910. Larvæ about full grown, one-half natural size. (Original.)

LIFE HISTORY STUDIES.

The work now in progress promises to result in an extensive number of records of the complete life cycle of individuals from egg to adult stage. Already several dozen larvæ have been carried to near maturity

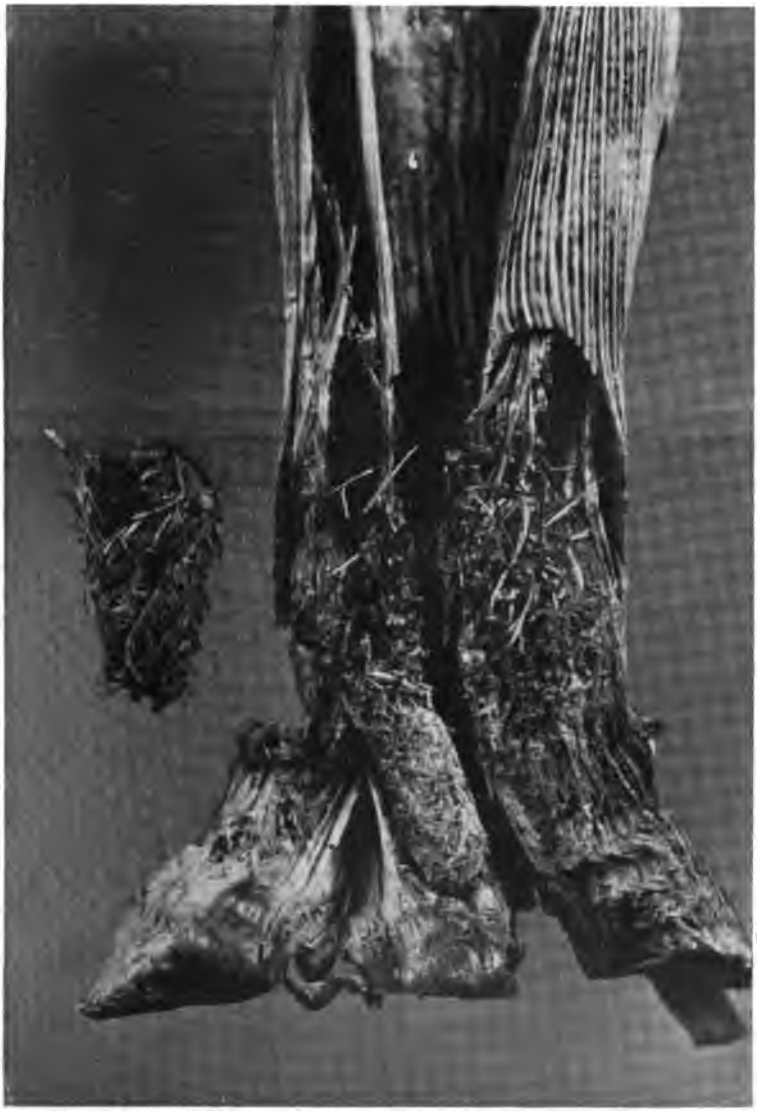


FIG. 11.—*S. callosus.* Cocoons Formed of Corn Fiber for Protection of Pupa. Empty cocoon on left was formed in the soil just beneath corn stalk in which the larva completed its growth. Cocoon shown in corn stalk was photographed in natural position at lower end of feeding cavity. See Fig. 8, showing the other side of this cocoon and the live pupa.

(Original.)

and some will pupate within a few days. The eggs are hatched either in glass vials or tin boxes and the larva as secured are placed carefully in a hole cut into a young corn root. In this manner the larva are given food almost exactly similar to what they get in the field, and it has not been found difficult to get them to feed and grow rapidly, even though partly disturbed each day for the purpose of determining the number of molts and their rate of development.

This work is requiring constant attention and careful manipulation, but the results are promising.

Larvæ of all ages, and in all stages of development are being preserved for measurement and microscopic examination when time permits.

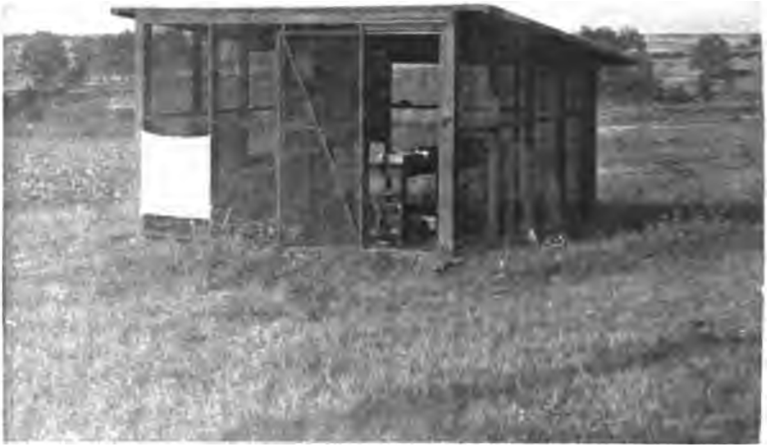


FIG. 12.—Outdoor Laboratory for Studying Life History of Insects. This structure is built with light wooden frame, covered with ordinary 12-mesh wire screen.

All the above statement refers to *Sphenophorus callosus*, unless otherwise stated. This species is the one that causes all the damage reported from the eastern counties. So far as the writer knows this species has never been recorded as feeding on corn in the vicinity of Raleigh. The observations made this spring seem to indicate that, while the species is quite numerous here, and breeds freely in yellow nutgrass, *Cyperus esculentus*, in the early summer and, later, in Elegant Nutgrass, *Cyperus flavicomus*, also, it does not naturally cause much damage to the young corn. During the last two months the field observations have shown that young corn is often attacked, but no real injury, except for a few plants, has been observed. To one familiar with bill bug work it is easy to tell where the bill bugs have fed, even after the corn is nearly grown. The characteristic holes made by the bill bugs when the corn leaves are tightly rolled together and show prominently when the leaves expand, are certain evidence of bill bug work.

BILL BUG STUDIES CONDUCTED OUT DOORS.

All the life-history studies of bill bugs, egg-laying, egg-hatching, rearing larvæ, etc., have been conducted in a wire screened cage where the temperature and moisture conditions correspond almost precisely with field conditions. This outdoor laboratory is situated so as to get full exposure to light and air, and, except for having a roof to protect the material from storms, it is subject to all changes of weather. This has made it possible to conduct the work in such a manner that the results correspond closely with field conditions. The writer has carefully watched the development of bill bug eggs and larvæ in the field and finds that his cage experiments are practically identical with field conditions. In the end this will make the results of special value.

SPHENOPHORUS PARVULUS.

This small species of *Sphenophorus*, of which one female was collected on May 19, 1911, is not common here, but the writer has commenced a life history study of the species. Thus far no other specimens of this species have been taken here or elsewhere. Fertile eggs have been secured and the larvæ obtained are being reared in the same manner as the common species, *S. callosus*. The single female under observation has laid 63 eggs, commencing with three eggs on May 22; on June 30 three eggs were laid and the beetle shows no sign of stopping. The newly-hatched larvæ are very small and require very careful handling. The first larva was secured June 8, and since then several have hatched and are now feeding and growing satisfactorily.

a

b

A TROUBLESOME MITE.

Within the last few days a mite, *Tyroglyphus americanus*, Bks., has appeared in the experimental cage. This mite is a common laboratory pest in the Eastern States and as it often attaches itself to adult insects it is carried into the most unexpected places. It probably came to the cage on some material collected in the field. Just how troublesome this mite will prove to be is hard to tell, but when it appears in a section of corn stalk in which a young *Sphenophorus* larva is living it becomes necessary to remove the larva to fresh food, thus requiring much extra work, besides making it difficult for the larva to develop naturally. A small weak larva is usually killed and devoured by these mites, but the larger larvæ are often able to protect themselves.

x

THE HOUSEFLY (*Musca domestica*).

BREEDING PLACES OF HOUSEFLIES; COW MANURE PROVEN TO BE IMPORTANT SOURCE; SUCCESSFUL USE OF FORMALIN IN MILK AS A FLY POISON.

BY R. I. SMITH, ENTOMOLOGIST.

This report covers work done by the writer during June and July 1911, while attempting to reduce the housefly nuisance around the A. and M. College dairy and horse barns, and in the West Raleigh section. Although no systematic experiments were planned more work was done than was at first anticipated, and the information and results obtained were of such a nature as to make it seem advisable to furnish this report. One principal result of this work was in determining that flies breed in large numbers in the cow manure from the dairy barns, and in the calf stalls, wherever a large number of animals are kept, as well as in the horse stables, whence most of the houseflies have been supposed to originate. Another important feature of the work was the demonstration of a successful method of using 40 per cent formalin with sweet milk as a fly poison. By combining the two methods of preventing the breeding of flies by weekly removal of all stable manure, and by poisoning great numbers of flies with formalin mixture, the fly nuisance at the A. and M. dairy barns was reduced to a minimum, so much so that during July the flies were reduced to much less than one-tenth their usual number. The formalin method of poisoning flies was taken up by the citizens of Raleigh and vicinity and in other towns throughout the State as a result of newspaper articles furnished the local daily papers. It has been learned that fly screens have been placed in many houses which have never before been screened. Even the Raleigh City Market was thoroughly screened after this warfare on the housefly was inaugurated. Formalin-milk poison was used successfully in the city market after the place was first screened. The local druggists sold many gallons of formalin within a few days after the success of this treatment was made known through the Raleigh papers.

Press Bulletin No. 23, entitled "How to Suppress Houseflies," was written and published under date of June 20, and mailed to all the newspapers of the State. This Bulletin, in addition to the articles which the writer prepared for the local daily papers, aroused considerable interest in the housefly situation. It should be stated here that additional interest was created by two articles prepared by Dr. F. L. Stevens, Bacteriologist, concerning the ability of houseflies to carry disease germs, thus emphasizing the danger of houseflies as a conveyor of typhoid fever and other intestinal diseases. These articles appeared in Sunday editions of the Raleigh *News and Observer.*

The actual observations and work recorded herewith had to be conducted at irregular intervals as the writer's time was principally needed for an investigation of the corn bill bug. For this reason no excuse is offered for the apparent incompleteness of some of the experiments and observations recorded.

During the latter part of May, 1911, the houseflies became unusually numerous and troublesome in the West Raleigh section, and the same condition was true in the city of Raleigh. A few cases of typhoid fever about this time served to emphasize the necessity for some attempt to suppress the flies. On May 22, 1911, Director Williams sent a circular letter to the residents of West Raleigh, in which the A. and M. College is located, asking for some coöperative attempt to reduce the houseflies. The writer was requested to determine where most of the flies were breeding, and to make such experiments as seemed advisable to destroy them, both by attacking the larvæ and pupæ in their breeding places, and by poisoning or trapping the adult flies.

FIG. 13.—The Old Method of Housing Stock. Houseflies breed by the thousands in the manure that is usually allowed to accumulate for weeks or months.

BREEDING PLACES.

Stable manure of all kinds was found to be literally swarming with maggots, of which a large per cent proved to represent the true housefly. The horse and mule stables were first investigated, and in every one, where the manure had not been removed within the previous two weeks, the maggots were present in great numbers, while the presence of many empty pupal cases showed conclusively that adult flies were emerging every day. This of course was to be expected, as horse manure is recognized as a common breeding material.

HOUSEFLIES BRED FROM COW MANURE.

The cow manure accumulated around the dairy barns and calf stalls was next examined. In it the maggots were present in enormous numbers, and on several occasions bunches of both recently formed pupæ and empty pupal cases, were discovered. It was very apparent that the maggots which swarmed through the manure were inclined to congregate in certain corners or crevices and pupate in a mass, often nearly as large as one's fist, such masses sometimes containing over a thousand pupæ. smaller masses of pupæ and empty cases from which the flies had emerged, were also found. Scattered pupæ were discovered around the edges of the piles of cow manure and even in the soil underneath where the maggots had burrowed before pupating. These last observations are important for they may explain in some measure the reason why many writers have stated that cow manure is not an important source of houseflies.

About July 10 a number of pupæ were collected from underneath a pile of cow manure, which was almost pure except for a little straw and ensilage used for an absorbent. From this lot 76 flies emerged and all but one proved to be the true housefly. The other one was the biting stable fly, *Stomoxys calcitrans*. Those flies were sent to Washington and identified by Dr. L. O. Howard of the Bureau of Entomology. Dr. Howard stated in his letter, "they are undoubtedly the housefly," but commented further: "The fact that the cow manure was mixed with straw and ensilage accounts for the houseflies being able to breed to such an extent." In the writer's opinion this simply emphasizes the danger of cow manure being a source of flies, for in this State nearly everyone uses considerable absorbent in the cow stalls and calf pens.

OTHER SOURCES OF FLIES.

Aside from the flies emerging from all kinds of stable manure, perhaps the most dangerous source is the open privy, as the flies emerging from such situations are more liable to convey the germs of typhoid fever and other diseases. Any accumulation of decaying vegetable matter, neglected garbage cans, etc., may serve to breed flies. One loathsome condition that came to the writer's attention was that of finding maggots in the dirty linen from a restaurant when received by the laundry to which it was sent.

Without going into further detail it may be stated emphatically that the principal source of house flies is from stable manure, but there are always minor sources that can readily be removed when the residents of any vicinity commence an active campaign.

ATTEMPTS TO KILL HOUSEFLY MAGGOTS IN MANURE.

Kerosene.—The liberal use of kerosene on horse manure has been tested at Washington, D. C., with rather unsatisfactory results. Although aware of this fact the writer made one test with kerosene on cow manure in which the maggots were swarming. Two gallons of kerosene were sprayed over about 25 square feet of a manure pile. It was found that this quantity did not soak in over about one inch deep, and only a very few maggots were killed. It seemed that the maggots near the surface simply worked down out of reach of the kerosene, for otherwise they could not have survived the treatment. On the day following there was practically no indication that the kerosene had had any beneficial effect.

After 24 hours it was so nearly all evaporated that the odor was not strong and the adult flies were hovering over the pile in their usual numbers.

Acid Phosphate Mixed With Cow Manure.—To determine the chance of improving the fertilizer value of cow manure and at the same time prevent the housefly maggots from developing in it, 16 per cent acid phosphate was tested by mixing 200 pounds with about 2,000 pounds of manure. The test was commenced by taking all of one day's accumulation of manure from the dairy barn, amounting to about 200 pounds, and mixing in 20 pounds of acid phosphate. The manure was piled in a smooth place out doors. Three days later the same amount was taken and mixed in the same manner and piled on top of the first; the sixth day's manure was similarly treated and thrown on the heap. This pile was kept for two weeks and frequently examined. For comparison, an untreated pile of manure from the same source was kept beside the treated pile. This experiment proved entirely worthless from the standpoint of killing the maggots, as they were present by the thousands in both piles when the experiment was discontinued.

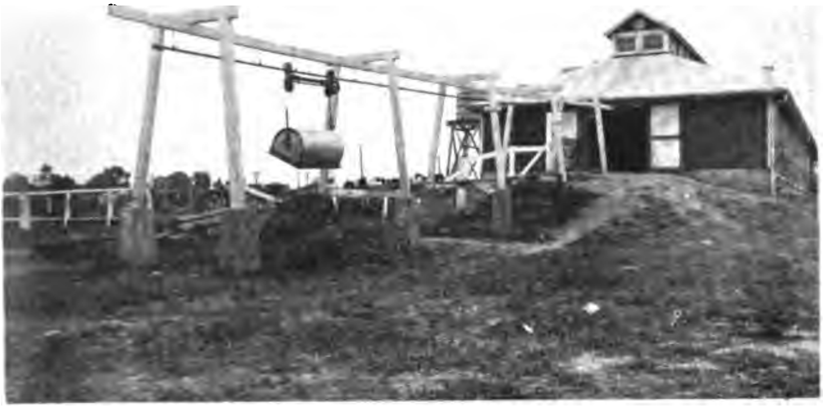


Fig. 14.—The Modern Method of Handling Stable Manure. Houseflies prevented from breeding by removing the manure from the stable every day and hauling the pile away at least once a week.

The manure treated with acid phosphate contained as many maggots as the untreated pile. Both piles were kept until some pupæ were formed, showing that the maggots had commenced to mature.

A second test with acid phosphate was afterward made, using 400 pounds to about 2,000 pounds of cow manure, but the result was the same as when only 200 pounds were used.

Floats.—An experiment was made to determine the value of floats (finely ground phosphate rock), mixing 400 pounds with about 2,000 pounds of cow manure. The experiment was conducted in the same manner as that just recorded for acid phosphate, and the result was the same.

Formalin Solution (4 per cent).—After formalin solution for poisoning adult flies had been successfully used, as recorded below, the writer was asked to try a 4 per cent water solution of formalin on a pile of manure. This experiment was made about the middle of June. A pile of cow manure literally swarming with maggots was selected and sufficient liquid applied to soak in around the maggots. In fact, care was taken to actually saturate certain spots where the maggots were most numerous. This treatment proved practically worthless; possibly a few maggots were killed, but examination of the manure did not show it.

Disinfectant Sprays in Box Stalls.—The liberal use of disinfectants, such as Creolin, Zenoleum, etc., applied three or four times a week to the walls and floor of box stalls serves to keep flies out to some extent, but the writer's observations lead him to believe that such applications are of comparatively little value as usually used. Some disinfectants have been used in box stalls at the College barn, but never with great success. The amount of disinfectant necessary to actually keep the flies from entering and depositing eggs, renders the treatment too costly and troublesome. A disinfectant lightly sprayed over the manure has no effect whatever on the maggots which are already present.

All the work conducted shows that the weekly removal of all stable manure, and that accumulating in the yards or piled outside, is the only way to really prevent flies from breeding around the barns. When this method is properly carried out formalin poison may be used to eradicate many of the flies. As already stated it was by this combination of removing the breeding material and killing adult flies that the flies at the A. and M. College barn and dairy were so effectively controlled during June and July.

FORMALIN-MILK MIXTURE SUCCESSFULLY USED AS A FLY POISON.

Early in June, 1911, experiments were commenced with a commercial grade of 40 per cent Formalin for poisoning the houseflies around a dairy barn and milk room, where they were extremely numerous. Previous to that time the flies had been increasing rapidly in the horse stables, calf stables, and around the dairy barn, from which places the manure had not been removed for several weeks. The conditions, therefore, were ideal for a conclusive test of the formalin as a poison. Furthermore, in this situation the flies had abundant material for food, in the milk room where the milk was strained twice a day and in the stables and stock yards. Plenty of water was always present, a thing on which flies are very dependent. Under these conditions it would not have been surprising if the flies had refused to feed on the formalin-milk mixture, but fortunately the experiments were successful.

FORMALIN-MILK MIXTURE.

Formalin has been used more or less for several years as a fly poison, usually mixed at the rate of 1 part to 20 parts of sweetened water. Realizing that flies are especially fond of sweet milk, my first experiment was to use 1 ounce of formalin in 16 ounces (one pint) of new milk. The first experiment was successful. The formalin-milk mixture was exposed in four plates on the floor of a milk room which was about 15 feet square. The mixture was first exposed about three o'clock one afternoon. Flies commenced to feed and drop dead within a few minutes and continued to die rapidly even while the evening's milk was being brought in and strained. Flies continued to feed and die until dark, and commenced feeding freely again about daylight the next morning. About eight o'clock a. m. the dead flies were swept up and found to measure over one pint, or between five and six thousand in number.

This experiment was repeated for three successive days, exposing a fresh lot of formalin-milk mixture each day about two or three o'clock, and sweeping up the dead flies the following morning. Fully one pint of flies were secured each time, and the number present in the milk room appeared to be considerably reduced. As the milk room was at that time unscreened and flies abundant through the barns and around the manure piles, the poisoning in one small room could not, of course, greatly reduce the numbers, but it proved the value of the mixture as a fly poison.

My next experiment was to determine if a mixture of milk and water, containing formalin, would be as attractive as the whole milk. For this test milk and water were mixed in equal parts and one ounce of formalin added to 16 ounces of the diluted milk. The result was satisfactory. Flies seemed to feed on this as well as on the whole milk mixture.

Formalin was tested in various proportions, using one ounce in ten ounces of whole milk or diluted milk, and at other strengths up to one ounce in twenty ounces of milk or diluted milk. It was found that all proportions were quite effective, but in some cases the strongest mixture seemed to repel the flies, while the weakest did not kill them quickly, and probably a few at least revived, after being partly disabled by the formalin.

Without mentioning details of the various experiments it may be stated that the formalin mixture which gave best average results and which the writer has recommended ~~in newspaper articles~~, is as follows: "1 ounce (2 tablespoonfuls) of 40 per cent formalin, 16 ounces (one pint) of equal parts milk and water.

"This mixture should be exposed in shallow plates, and by putting a piece of bread in the middle of the plate it furnishes more space for the flies to alight and feed and in that way serves to attract a greater number of them.

"Whole milk can be used, but the diluted milk seems to be just as successful."

Formalin can be purchased at retail price at fifty cents a pint, hence the treatment is not expensive.

POISONING FLIES IN A CALF BARN AND PIG PEN.

A very conclusive test of the efficiency of the above formalin mixture was made in a large calf barn where flies were extremely numerous. Six plates of the mixture prepared like the above formula, were placed in the passageway between the stalls. This passage is about six feet wide and thirty feet long. The poison mixture was exposed at 12 o'clock, noon, and left until 8 o'clock the next morning. The dead flies when swept up measured three quarts, and certainly one-half as many died in the stalls on each side. I estimated that between forty and fifty thousand flies were killed in twenty hours by this experiment.

Another proof of the value of the formalin-milk mixture was secured by using it in a pig pen. A pen of young pigs located near the calf barn mentioned above was found to contain thousands of flies attracted by the milk used for feeding. As it was not possible to put the formalin mixture in the pen itself, a board was nailed across the top, at a height of about three feet. On this board three medium sized tin plates were fastened to receive the poison mixture. The experiment was started about 4 p. m. and within thirty minutes it is estimated that about 1,000 flies were dead or partly overcome by the formalin. At first the flies did not readily find the plates. It would no doubt have been much better to have confined the little pigs and have placed the plates near the feeding trough. However, this test was successful. The flies continued to feed and die rapidly that afternoon and again the next day, when fresh mixture was exposed. It is interesting to note that after the first half-hour or so the little pigs commenced to eat the dead flies, and after that a fly was hardly allowed to drop before being eaten. The pigs must have consumed a quart or more of flies within a couple of days and showed no symptoms of being injured by them.

CHICKENS CAN SAFELY FEED ON FLIES KILLED BY FORMALIN.

I have fed dead flies, killed by the formalin treatment, to chickens without any injury. Furthermore, I have been advised by a resident of West Raleigh that his chickens consumed the dead flies in great numbers.

This party stated: "We have used the formalin according to your directions, on our back porch and in the back yard, and have killed flies by the thousands. Our chickens eat most of the dead flies and it does not seem to hurt them."

PRACTICAL USE OF FORMALIN AS A FLY POISON.

The experiments recorded above prove that we have demonstrated the efficiency of formalin as a fly poison. It is true that the formalin, if used in the same proportions with sweetened water, will often be very effective, but the milk makes a more attractive bait and in most situations more flies will be killed when it is used instead of sweetened water.

At the writer's suggestion many housekeepers in Raleigh and West Raleigh have used the formalin-milk mixture as recommended above, and several have reported the killing of flies by the pint and quart. A gentleman in charge of a farm where a large horse barn is maintained tells me that he poisoned a gallon of flies the first day he tried the mixture. This statement was vouched for by other witnesses in whom I have perfect confidence.

A good place to expose the formalin mixture is on the front and back porches, where flies are frequently numerous, and waiting to enter when the doors are opened. I know of several people who have used it successfully in this manner.

The use of the formalin-milk mixture in dwelling houses has not proved so successful, except in unscreened kitchens or dining rooms.

This poison was tested in the large college mess hall, where over four hundred students can be seated, resulting in practically cleaning up all the flies in two days. Previous to that time the steward had been using tanglefoot fly-paper, often having as many as thirty sheets exposed. Fully that number were present when the formalin was used; but in spite of them the flies were numerous.

Many entomologists and others who have read the many published articles concerning houseflies probably know that formalin, as a fly poison, has often been condemned, especially, perhaps, during 1910. I am of the opinion that these failures have been due to not using the formalin in an attractive medium, such as milk. It is true that a few people have reported no success with formalin-milk mixture, but I know of several who commenced using it in the wrong proportions, either too strong or too weak, with very little success, but who afterwards mixed it in the proper proportions and at once found that it killed the flies as the recorded experiments amply demonstrate.

OKRA WILT (*FUSARIOSE*), *FUSARIUM VASINFECTUM*, AND CLOVER RHIZOCTONIOSE.

By F. L. Stevens and G. W. Wilson.

The okra wilt prior to this has not been recorded in North Carolina, indeed no record of it at all has come to our notice except the rather vague mention by Smith in 1899[2] and one of its occurrence in Connecticut by Clinton.[3] Dr. Orton writes us that he has records of its collection at Baldwin, Ala., at Dwin, Pa., and at Edisto Island, S. C. The disease is perhaps not of serious importance since the okra can hardly be regarded as a plant of high economic value, though it is a delicacy prized by many and raised quite extensively.

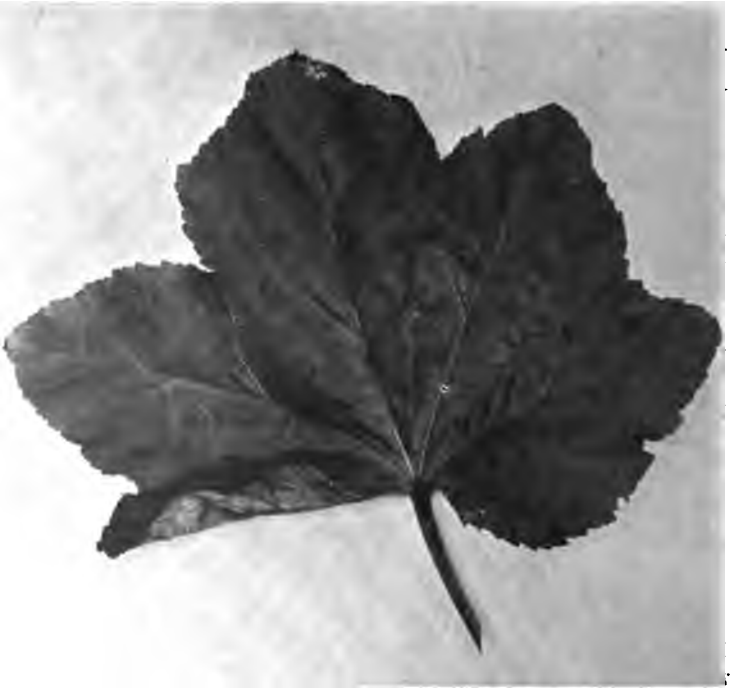


Fig. 15.—Okra leaf affected with wilt.

The present disease partakes of the type of the wilt class of soil diseases. It is due to a fungus which hibernates in the soil and from the soil invades susceptible plants grown there. Soil which has once become infected will in the future cause disease to susceptible plants, the causal fungus remaining for indefinite periods in the soil.

---

[2] Smith, E. F., U. S. Dept. Agr., Div. Veg. Path. Phys. Bul. 17, Nov. 1899.
[3] Clinton, G. P., Conn. State Sta. Rpt. 1905: 269.

The disease is of especial interest on account of its close kinship to the disastrous wilts of cotton, cowpea, and watermelon, with which it is perhaps identical. The fungus causing these diseases was first described by Atkinson in 1893 as *Fusarium vasinfectum.*[4] It was later made the subject of extensive study by Smith.[5]

Smith concluded that an ascigerous fungus, which he named Neocosmospora and which he found on the diseased plants was the perfect form of the Fusarium which causes the disease. He consequently renamed the fungus Neocosmospora vasinfectum. Later research by B. B. Higgins,[6] of this laboratory, and Butler,[7] of India, strongly indicate that the Neocosmospora is merely a superficial saprophyte and that it has nothing to do with causing the disease. Since the fungus in hand can not be distinguished from *Fusarium vasinfectum* as described by Atkinson[8] on cotton we so designate it here.

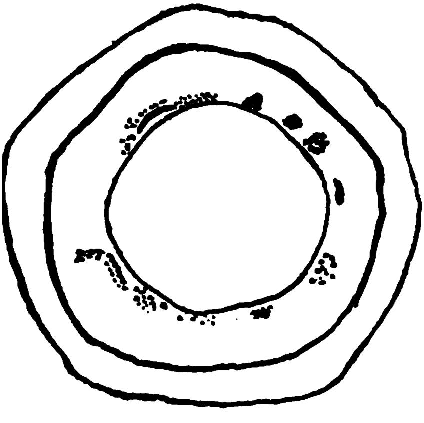


FIG. 16.—Section of upper portion of infected okra stem.

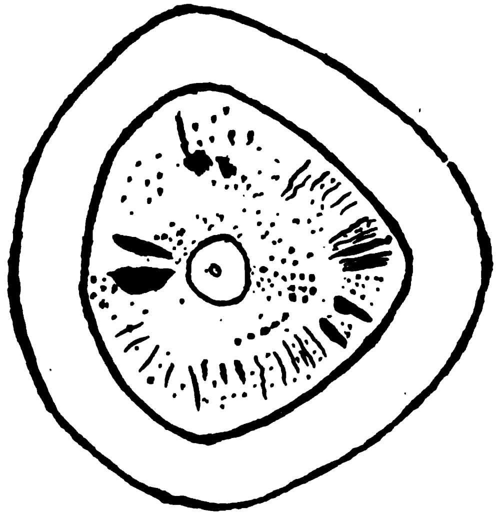


FIG. 17.—Section near base of infected okra stem.

DISEASE ON OKRA.

In general the disease agrees closely with the wilt of cotton as described by Atkinson.[9] The first symptom is the wilting of a portion of a leaf, usually the part most distant from a main vein. This wilting is accompanied by loss of green color, a gradual change to yellow or white, followed by death of the tissue, and browning. If the dead portions be near the margin the leaf may roll or curl. Fig. 15. Cross section of the petiole of such leaf reveals blackened strands running lengthwise through the woody parts. If these strands are located mainly on one side of the petiole the corresponding side of the leaf f exhibits symptoms of disease. Sections made in the stem below t point of attachment of a diseased leaf show these dark strands ru- ning down the stem, and as the base of the plant is approached the d strands increase largely in number. Figs. 16 and 17. In the r a similar condition is met. Some roots bear so many dark strands t the whole of the wood is almost black. Other roots may be norm and uninfected.

---

[4] Atkinson, G. F., Alabama Sta. Bul. 41: 19-21.
[5] Smith, E. F., U. S. Dept. Agr., Div. Veg. Path. and Phys., Bul. 17.
[6] Higgins, B. B., Science, N. S. 31: 916. 1910; and Ann. Rep. N. C. Sta. 1909: 100-116. 1911.
[7] Butler, E. J., Mem. Dept. Agr. India, Botanical Ser., Vol. 2, No. 9. 1910.
[8] Loc. Cit.
[9] Atkinson, G. F., U. S. Dept. Agr., Office Expt. Sta. Bul. 33: 287. 1896.

FUNGUS IN THE HOST.

The gross character, indicating the presence of the fungus in the h is the blackening of the walls of the vascular bundles in the infe area. Closer examination shows these diseased bundles to contain mo or less abundant whitish or brownish mycelial threads. These increa

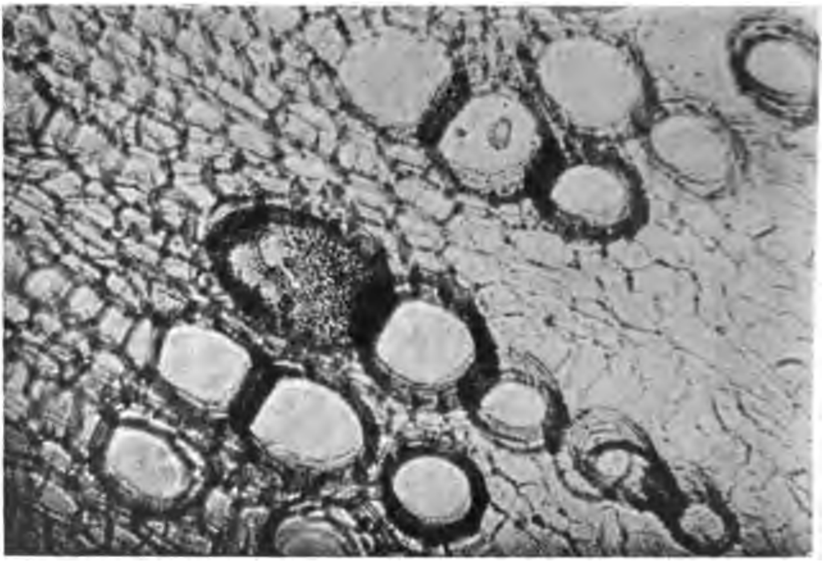


FIG. 18.—Photomicrograph showing vascular bundles of diseased okra stem.

in abundance with the progress of the disease until at last the tubes are filled completely with the interwoven hyphæ, causing a cessation of the sap flow and consequent wilting of the host.

ISOLATION OF THE FUNGUS.

Sections from diseased stalks were placed in a moist chamber and in a few days were covered with a growth of hyphæ bearing conidia of the Fusarium type. Shreds of diseased tissue were also placed in petri dishes with agar and developed the same fungus, which was kept under observation in pure culture for some months.

FUNGUS IN CULTURE.

The fungus grew freely in cultures of pea-agar and was constant in its characters, which agree well with those of *Fusarium vasinfectum*. Conidia were produced in abundance. Perhaps the most interesting feature developed in the cultures was the uniform presence of numerous black sclerotia-like bodies similar in structure to those described by Appel and Wollenweber,[10] for *F. Solani* and related species. These appear to be of the nature of sporodochia, as they are associated with conidia production.

CLOVER RHIZOCTONIOSE.

During the past season several complaints came to the Station of a crown disease of clover which was devastating entire fields. These reports came especially from Buncombe and Stokes counties. Rhizoctonia was abundant on the roots and was clearly the cause of the trouble.

About the same time an epidemic of "damping off" appeared in the horticultural greenhouse. Examination showed Rhizoctonia on seedlings of cabbage and scuppernong grapes and on cuttings of aucuba, berbeis, privet, loquat, laurel cherry, pomegranate, hibiscus, begonia, and cratægus.

---

[10] Appel, O., and W. H. Wollenweber, Arbeit. K. Biolog. Anstalt. f. Land. u. Forstwertschaft. Vol. 8, part 1, plate 1, Fig. 23, 59, etc. 1910.

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
WEST RALEIGH

C. B. WILLIAMS, *Director.*

PRESS BULLETIN No. 22
JANUARY 25, 1911

USE OF LIME ON THE FARM

Because of a misconception as to the action of lime there is much misuse of lime by a goodly number of farmers. In many cases where marked results have followed the use of this material the conclusion has been drawn that it is the only one that needs to be added to the soil in order to secure large yields annually thereafter. Such a conclusion is not justified by the facts in the case, and if this material is used and depended upon entirely it will be found in time that the beneficial results will gradually grow less. There is no truer saying than that the indiscriminate use of the lime enriches the father but beggars the son if it is depended upon solely for average soils. It should be remembered that, although lime is as essential for plant growth as phosphoric acid, nitrogen and potash, it is not able to replace any one of these nutrients in the promotion of plant development.

UNDER WHAT CONDITIONS USE.

As a direct plant food for such crops as corn, cotton and the small grains planted on most of our soils, it is seldom needed, but for leguminous crops, such as the clovers, vetch, peas and alfalfa, its use is usually imperative for the best returns with those soils not well supplied with lime. It might be stated in this connection that as a general rule with most of the upland and coastal soils of the State it is generally necessary to use an application of lime to secure the best results with the growth of leguminous crops. Usually the most marked results with general farm crops have followed the use of lime on soils which have been allowed to get into a bad physical condition or to become sour or acid, either through a large accumulation of organic matter, poor drainage or insufficient aeration brought on by poor preparation and cultivation, or all combined. The writer has seen applications of lime to soils which have been allowed to get into a sour condition change the yields of corn in one year from a complete failure the previous year to splendid yields the year following the application of lime. In cases like this—and there are many such soils in the State—the chemical and physical conditions of the soil were such that, although the soil had abundant plant food for large yields for many years, yet ordinary crops like corn would not grow to any extent until these conditions were made suitable for their growth. When lime was added it neutralized or destroyed the acidity of the soil, and at the same time improved its physical and chemical condition and biological character to such an extent that afterwards for years the yields were good. Here the beneficial results are largely due to the favorable action of the lime on the soil rather than in supplying lime as plant food to the crop. In addition to supplying plant food and improving the chemical, biological and physical condition of the soil, lime hastens the decomposition of organic matter in the soil, liberating much of the inert or locked-up nitrogen contained in the organic matter or humus. Also the store of inert potash and phosphoric acid of the soil is acted upon by the lime, and a decidedly larger percentage is brought into an immediately available form annually for plant growth than would have been through ordinary agencies operating in the soils. Hence lime tends to hasten the exhaustion of these constituents of the soil rather than build the soil up, especially when the lime is used alone, continuously, without fertilizer, on poor soil.

HOW DETERMINE WHEN LIME IS NEEDED.

If the land contains a large amount of organic matter (usually indicated by dark color of the soil) it is fairly safe to assume that such soils, if crops do not yield well on them and they have not received an application of lime or marl in recent years, that they would be benefited by liming or marling.

If sheep sorrel, button weed and the water grasses are growing in the fields it will usually be found that such soils will respond favorably to applications of lime. If blackberries, cranberries, raspberries or gallberries are growing wild on the same type of soil in close proximity to the field in question, it will generally be found that an application of lime will prove beneficial for ordinary crops like corn and the small grains on such a field.

If it is an old field that has been robbed of its humus by continuous cultivation in some clean cultured crop, like cotton, and the soil of which runs together and cements after each rain, it is quite likely to respond profitably to an application of lime, especially for the growth of such crops as clover, vetch, peas and other legumes. If a heavy growth of some green crop is turned under, especially in the spring, an application of lime or marl should be made before turning in order to prevent the formation and accumulation of a large amount of organic acids in the soil by the rotting of the crop turned under. If the soil has been poorly drained, and has become tight and water-sogged, lime will in most cases prove highly beneficial when applied soon after drainage and before a crop has been put in. If clover, vetch, cowpeas and peanuts are to be grown upon ordinary upland soils, it will usually pay to make a good application of lime to the soil, the best results usually following with cowpeas, if the application is made to the crop growing previously on the land; while with peanuts the opposite is frequently true.

If a soil is quite acid its presence may be determined by means of litmus paper. Take a portion of the soil to be tested into the hand and make it into the consistency of a mud pie by adding water and working with the hands. Now take a small strip of blue litmus paper, which may be secured from any local drug store, and bury it in the mud pie. After remaining for a minute or two remove the litmus paper and wash in clear water, and if the soil is acid or sour the color of the paper will have been changed from the original blue to a red color. Of the commonly grown farm crops probably oats and Irish potatoes are the most tolerant of large amounts of acidity in the soil.

WHEN APPLY.

Although conditions and systems of rotation will modify to some extent the time of application, yet, usually, the safest time to apply this material to the soil will be during the fall or early winter, especially so if either the caustic or slaked form is used. If carbonate of lime be employed it may go on in the spring with less danger of injury to the seed of the crop than when either of the two forms mentioned above is used. When the application is made in the fall, time is afforded for the lime to become well mixed with the soil before spring, especially so if it is put in properly. The carbonate or air-slaked form of lime does not act as energetically as do the quick and water-slaked forms.

HOW APPLY AND AMOUNT.

As a general rule lime should be applied broadcast and then thoroughly harrowed and disked into the soil. Of slaked lime the quantity required per acre varies quite considerably with different soils, crops and conditions. Usually, however, the amount necessary to use will vary between 1,000 and 3,000 pounds, or its equivalent of some other form, per acre. Never mix lime, especially in the caustic or water-slaked forms, with any material containing ammonia, before applying it to the soil, because the lime would tend to set free into the atmosphere some of the ammonia, and hence it would be lost. For this reason it is exceedingly unwise to mix lime directly with stable manure. Do not add lime to acid phosphate or to mixtures containing this material, for such a procedure would result in some or all of the available phosphoric acid of the acid phosphate being changed to a less soluble or available form, the amount changed being governed largely by the proportion of lime to acid phosphate in the mixture and by the mechanical condition of the mixture.

When lime is added to permanent pastures and meadows it should be applied broadcast in the fall or early winter and left on the surface. For this purpose the carbonate form will usually be found best suited.

FORMS OF LIME AND THEIR EQUIVALENTS.

There are three chemical forms of lime used commercially other than gypsum (land plaster) or sulphate of lime. Each of these forms are known by a goodly number of names. The forms and synonymous names are as follows:

(1) Caustic, quick, burnt, builders, rock, stone or unslaked lime.
(2) Carbonate, agricultural, marble, limestone, marl or air-slaked.
(3) Water-slaked or hydrated lime.

As all three of these forms of lime are suited for agricultural purposes it becomes important in purchasing to know the relative equivalents in actual lime (calcium oxide). When 178 pounds of a good grade of carbonate of lime is burnt in the kiln about 100 pounds of quick or caustic lime is secured, the remaining 78 pounds of the original substance is driven off into the atmosphere as carbon dioxide or carbonic acid gas. If the above 100 pounds of quick lime, secured by burning, is exposed to the atmosphere for some time, it will absorb carbon dioxide again from the air, and will, when fully saturated with it, weigh 178 pounds. If 56 pounds of the burnt or quick lime is water-slaked with just enough water to complete the chemical change, the resulting hydrated or water-slaked lime will weigh about 74 pounds. In other words, 100 pounds of quick lime will take up in chemical combination about 32 pounds of water, thereby increasing its weight about one-third by water-slaking.

From the above it may be seen that the most concentrated form of lime is the caustic or burnt lime. This being so, where the lime has to be freighted long distances on the railroad or hauled several miles on country roads, or both, it will usually be found that this will be a cheaper form in which to buy lime, but not always. For instance, the freight on a carload of carbonate of lime (agricultural lime so called) will be the same as that on the same amount of quick or burnt lime, yet there would be almost twice as much actual lime (calcium oxide) in the latter as in the former, hence the freight on the lime contained in the quick form would be only about one-half of what the actual lime contained in the carbonate form costs per ton.

In securing quotations on lime do so upon percentage composition of calcium oxide and upon delivery at your nearest railroad station. If they are secured in this way it will not be difficult to decide from whom to purchase. If these precautions are not observed it will not always be easy to decide which will be the cheapest source from which to secure one's supply of lime. One bushel of good stone or rock lime will weigh about 90 pounds, and when slaked will produce about three bushels of slaked lime, which will weigh approximately 45 pounds per bushel.

Pure burnt oyster-shell lime weighs about 60 pounds to the bushel. When it is slaked about two and one-half bushels of slaked lime is formed, which will weigh about 40 pounds per bushel.

C. B. WILLIAMS, *Director.*

NORTH CAROLINA

Agricultural Experiment Station

WEST RALEIGH

C. B. WILLIAMS, Director

PRESS BULLETIN No. 23

JUNE 20, 1911

How to Suppress Houseflies

That the housefly nuisance in any community can be largely suppressed by united effort on the part of those who are interested can not be denied by any one who understands the situation.

The fly is not only disagreeable but is a menace to health. Typhoid fever and cholera infantum, and probably other intestinal diseases are often carried to victims by flies.

Steps should be taken in every community to commence a vigorous fight against this pest and it seems advisable to let every one become well informed about the breeding places of flies, and the methods of preventing them. Poisoning and trapping the flies is also of great importance.

LIFE HISTORY AND BREEDING PLACES OF HOUSEFLIES.

Flies originate largely from the horse, cow and mule stables. Cow manure will breed flies in great numbers, in spite of many reports to the contrary. In and around such places the flies lay their eggs. Fully ninety-five per cent of all the flies develop in the stable manure. Garbage piles, heaps of decaying vegetable matter, and any accumulation of filth may breed flies.

The eggs hatch in less than twenty-four hours into small, white, wriggling maggots.

The maggot stage of the flies lasts only five days in warm weather. Full grown maggots are about one-third inch long, with body pointed at the head end.

The full grown maggot changes to a reddish-brown pupa stage, about one-fifth inch long, which lives about five days, and then transforms to the adult winged fly.

A generation of houseflies, from egg to adult stage, may develop in ten or eleven days. *This shows that if the stable manure is hauled out once a week, flies will not have time to mature.*

Fully fifteen generations of houseflies mature during the summer.

Each female fly will lay about one hundred and twenty eggs, and this fact serves to account for the great numbers of flies where the breeding places are not done away with in a community.

Flies do not usually travel over a few hundred yards from their breeding places, so that it is entirely practicable, by united effort on the part of those who are interested, to do away with most of the houseflies in any community.

POISONING FLIES WITH FORMALIN.

There are several more or less successful fly poisons, such as Seibert's Poison Fly Paper, but the writer has had best success with *Formalin.* This costs only fifty cents a pint, and is used by placing *one tablespoonful in a half pint cup* of one-half each of milk and water. This should be exposed in plates, and it is well to put a piece of bread in the middle of the mixture to furnish more surface on which the flies can light and feed.

This formalin solution seems to attract the flies and kills them quickly. The writer recently poisoned over forty thousand (about 4 quarts of flies) in less than twenty-four hours in a calf barn where the flies were very numerous. In this manner thousands of flies are killed before they have deposited eggs.

When attempting to poison flies around dwelling houses it is best to expose the formalin poison mixture outside as well as inside the houses. Use it on the front and back porches where the flies are waiting to enter whenever the doors are opened.

We can never succeed in permanently lessening the fly nuisance by simply poisoning or trapping the flies, but when we attempt to prevent the breeding places, the work of poisoning the adult flies will be of great assistance.

Every citizen who is interested in the health and welfare of his family should determine where the flies are breeding and should not be suspicious of his neighbor's premises until he has made a careful search for the breeding places of flies on his own place.

R. I. SMITH, *Entomologist.*

BULLETIN 209 SEPTEMBER, 1910

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
OF THE
COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

SELF-STERILITY OF THE SCUPPERNONG AND OTHER MUSCADINE GRAPES

Edwards & Broughton Printing Co
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh
E. M. KOONCE	Jacksonville
T. W. BLOUNT	Roper
D. A. TOMPKINS	Charlotte
J. T. ELLINGTON	Smithfield
W. E. DANIEL	Weldon
W. H. RAGAN	High Point
W. B. COOPER	Wilmington
M. B. STICKLEY	Concord
T. T. BALLENGER	Tryon
N. B. BROUGHTON	Raleigh
O. L. CLARK	Clarkton
EVERETT THOMPSON	Elizabeth City
R. H. RICKS	Rocky Mount
O. MAX GARDNER	Shelby
M. L. REED	Asheville

STATION STAFF

D. H. HILL. President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. D. CECIL	Animal Pathologist
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station. the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

PAGE
Introduction ... 5
Self-sterility of Muscadine Grapes ... 5
Investigational Work ... 6
Typical Vines Tested ... 6
Bagging the Scuppernong ... 8
Bagging the Flowers ... 11
Bagging the James ... 12
Bagging the Thomas ... 12
Bagging the Mish ... 12
Germination Tests of Pollen ... 12
Microscopic Study of Pollen ... 14
Structure of Flowers ... 14
Number of Pistils that Develop ... 16
Influence of Male Vines ... 17
Apparent Exceptions ... 18
Exceptional Vine ... 18
Abundance of Male Vines ... 19
Application of Results ... 19
Kind of Male Vines to Plant ... 21
Weather during Blooming Season ... 22
Self-sterility not Always Responsible ... 22
Value of Pruning ... 22
Growing Seedlings ... 23

SELF-STERILITY OF THE SCUPPERNONG AND OTHER MUSCADINE GRAPES

BY

F. C. REIMER and L. R. DETJEN.

The subject of self-sterility is one of the most important connected with fruit culture. Horticulturists know that certain varieties will produce very little or no fruit when isolated or planted by themselves. It has been conclusively demonstrated that some varieties of plums, pears, apples, grapes, and figs must be planted near other varieties to make them fruitful. For example, the Wildgoose plum when planted by itself will produce very little fruit. While many orchards in the South solely of this variety are producing fruit, it is because every thicket or roadside contains many trees of the wild Chickasaw plum, which supply an abundance of pollen that is carried to the flowers of the Wildgoose plum by bees. The amount of fruit in such orchards decreases as the distance from these wild Chickasaw plums increases. The Kieffer pear, which is one of the most prolific of all varieties when planted in a mixed orchard, often bears very little fruit when planted by itself. There are many fig trees in this State which drop all of their fruit regularly because their flowers are not properly fertilized with pollen from other types of figs.

It can be understood that this is a question of great practical importance, and that one should know definitely before planting a certain variety whether it is self-fertile or self-sterile. Unfortunately, this question has not been answered for many of our fruits; the subject, therefore, offers a splendid field for investigation.

SELF-STERILITY OF MUSCADINE GRAPES

During the last few years great interest has been manifested in the Muscadine grapes—*Vitis rotundifolia*. In many instances large vineyards, sometimes exceeding a hundred acres in area, have been planted. One of the most important questions that has been asked by the leading growers is that relating to self-sterility. The Horticulturist of the Station has often been asked this question, and has had considerable correspondence regarding the matter. Letters have come not only from this State, but from other Southeastern States, and as far west as Texas.

If the variety is self-sterile it will be necessary for best results to plant and maintain in the vineyard male vines which do not bear any fruit. If the variety is self-fertile it would not be necessary to go to this expense. The question ought to be definitely and finally answered by experimental results.

The discussion of this question has become important because it has been variously answered by different people. This Station in two of its Bulletins has stated that the Scuppernong grape is self-sterile. A Bulletin from the South Carolina Station states that it is self-fertile. One of the largest nurserymen in the South maintains that the variety is self-sterile; and another leading nurseryman states that it is self-fertile. The growers and planters do not know whose advice to follow, as no conclusive evidence has been given. In April, 1909, this Station published Bulletin No. 201, which gave for the first time the results of experimental work on the problem of self-sterility in Muscadine grapes.

Our work on this problem has now been carried on for three years and we believe that the results are conclusive. These results should be of great value to grape growers.

INVESTIGATIONAL WORK.

A careful study has been made of self-sterility of Muscadine grapes by (1) bagging the flower clusters; (2) germination tests of pollen; (3) microscopic study of pollen; (4) proportion of flowers that develop fruit; (5) study of the structure of flowers; and (6) influence of male vines on crop.

TYPICAL VINES TESTED.

Representative vines of each variety were selected for this work. Some of the vines are noted for their heavy bearing quality; others are simply good average vines, typical of the variety. Only two very poor yielders were selected, of which special mention will be made. To make the results as conclusive as possible, the work was conducted

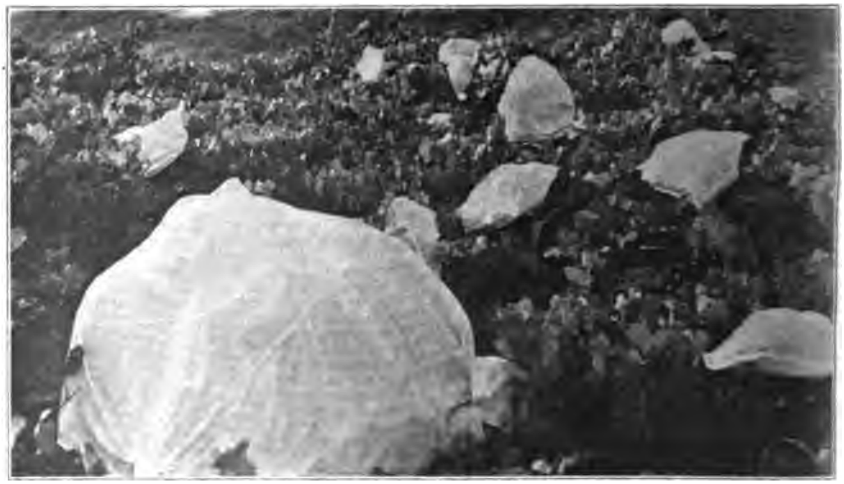


FIG. 1.—Vine showing covered branches and flower clusters.

in both the Lower Piedmont and Coastal Plain section of the State. All but one of the important varieties of this species originated in the Coastal Plain section of North Carolina. The work with two of the varieties was conducted in the vineyard in which they had originated; and in one case on the original vine itself. The Scuppernong vines were located on thirteen different farms; while the fruiting forms of the wild Muscadines were at eighteen different places.

BAGGING.

If a variety is self-fertile, its own pollen will fertilize the ovaries and it will develop fruit even though the flowers are covered during the blooming season so as to exclude foreign pollen. If the variety is self-sterile, it will require pollen from another plant to fertilize its flowers to bring the fruit to maturity. Covering the flowers of such a self-sterile plant during the blooming season would prevent the entrance of other pollen and prevent any fruit from setting.

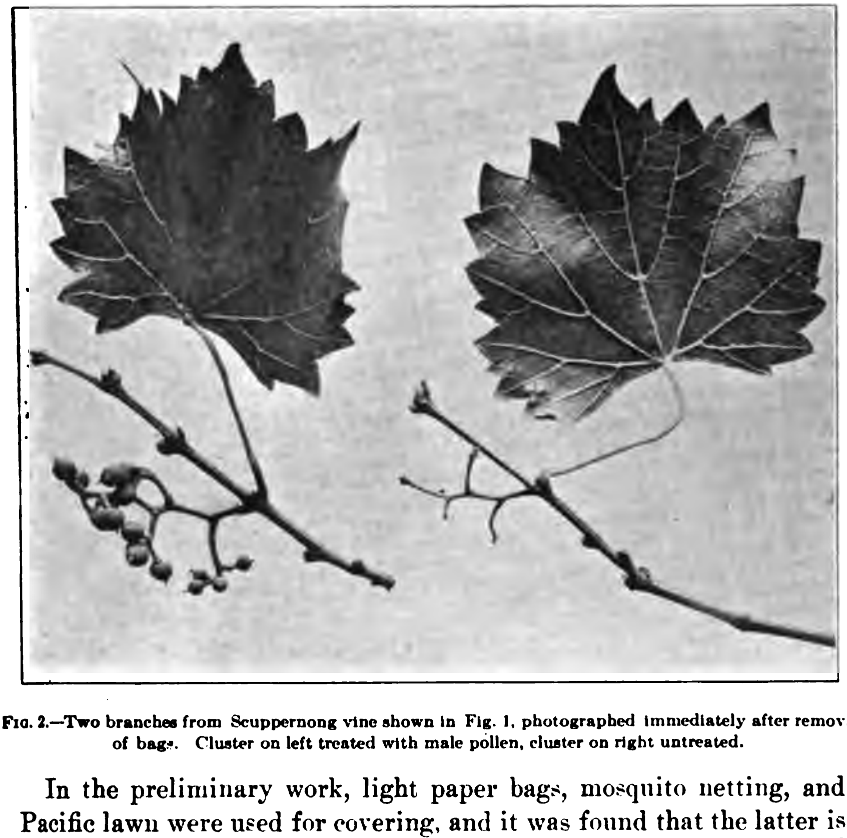


FIG. 2.—Two branches from Scuppernong vine shown in Fig. 1, photographed immediately after removal of bags. Cluster on left treated with male pollen, cluster on right untreated.

In the preliminary work, light paper bags, mosquito netting, and Pacific lawn were used for covering, and it was found that the latter is the most satisfactory material. It is light in weight, allows air and light to pass through readily, has very fine meshes, and is very durable. One hundred and thirty yards of this was made into bags varying in size from 4 x 6 inches to 3½ x 4½ feet.

The bags were put on just before the first flowers opened and left on until after the blooming season. Fig. 1 shows some of these bags on the vine. The number of flower clusters in each bag varied from one in the smallest bags to about four hundred in the largest. The flower clusters of the Muscadine are small and are borne mostly on short branches. The main branches are very much divided so that a bag 12 x 16 inches will often cover from forty to fifty flower clusters.

BAGGING THE SCUPPERNONG.

In 1908, twenty-five branches on two vines were covered. Twenty of these were left untreated, and no fruit developed on them. In the other five bags male flower clusters were tied to the Scuppernong flower clusters as soon as the flowers had opened; in three of these bags normal clusters of fruit developed.

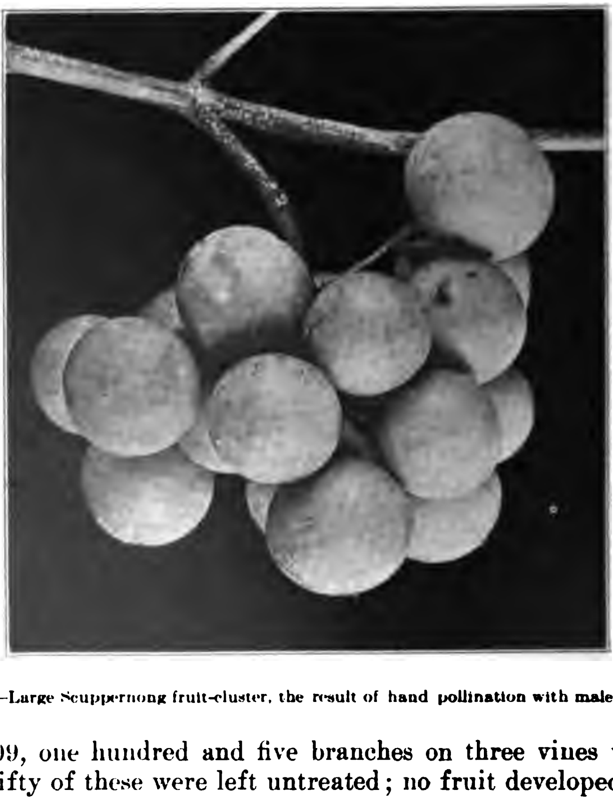


FIG. 3.—Large Scuppernong fruit-cluster, the result of hand pollination with male pollen

In 1909, one hundred and five branches on three vines were covered. Fifty of these were left untreated; no fruit developed in these bags. In the other fifty-five bags male flower clusters were inserted.

In eleven of these normal fruit clusters developed. The small proportion of bags containing fruit where male flowers were inserted was probably due to the fact that the male flowers had not opened when inserted, and many of them dried up before opening.

The most extensive work was done during the blooming season of the present year, 1910, when two hundred and sixty-four branches on six vines were covered. Two hundred and eight of these were left untreated, and one hundred and ninety-eight did not develop a single berry. The other ten untreated branches, which were all on one vine, gave some interesting results. Each of these ten bags contained from one to twenty-seven poorly developed, flat, seedless berries, from one-tenth to one-fifth normal size. Only two of these contained more than ten berries; the average of the ten bags being 6.8 berries to the bag. Two of these ten bags also contained one normal berry each with seed, and one bag had two small berries containing small, hollow worthless seeds. Three of the bags used on this vine were very large, each bag containing about four hundred flower clusters. The total

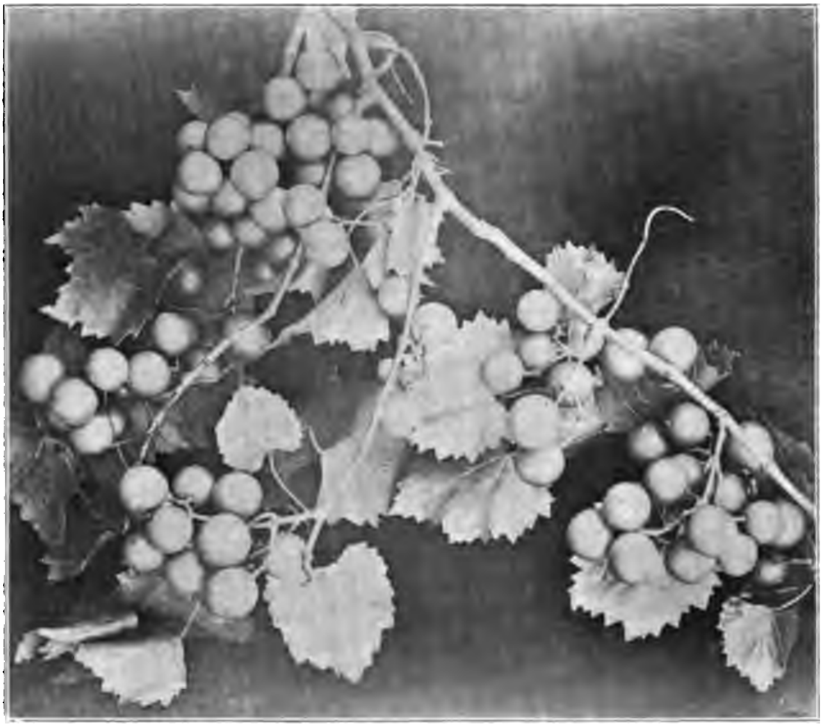


FIG. 4.—Branch of Scuppernong, showing crop in one bag where flowers had been hand-pollinated with male pollen.

number of flower clusters in these ten bags was about fourteen hundred. This gives an average of one small seedless berry to every twenty flower clusters, and one berry with seed for every seven hundred flower clusters on this vine. The seedless berries developed without any fertilization. The two berries containing normal seeds were properly fertilized, but we do not know how the male pollen got into these bags. It is possible that it was washed through the meshes of the sacks by rain.

The other fifty-six covered branches on these six vines were carefully hand-pollinated several times with pollen from a male vine. Fifty-three of these branches developed normal fruit. Most of these branches were heavily loaded, some of them containing at least ten times as much fruit as similar branches on the same vines which had not been covered, and were exposed to chance cross-pollination. The clusters in many of the bags were much larger than those usually produced by this variety; several clusters contained over twenty berries each. One small bag with several clusters contained one hundred and twenty-two large, normal berries.

On one of the most prolific Scuppernong vines under experiment four branches of practically the same size and all on the same arm were selected. These were not covered and hence were exposed to the visits of insects. Two of the branches were left untreated; these developed twenty-two berries. The other two were hand-pollinated several times with pollen from a male vine. One of these developed ninety and the other one hundred and seventy-one berries (Fig. 5). This difference was more marked than it would be in a more favorable blooming season.

One of the Scuppernong vines and two of the James vines worked with during 1910 were the most prolific vines that the writers have ever seen, but these proved to be self-sterile like all the others.

One of the Scuppernong vines used in the work in 1910 was eight years old but had never borne any fruit. Eight flower clusters were selected on this vine, six of which were covered with bags. Four of these covered clusters were left untreated; no fruit developed in these bags. But male pollen was applied to the flowers in the other two bags, and to the two flower clusters which were left uncovered; every one of these developed a good cluster of fruit.

As the stamens are short and reflexed in the flowers of the Scuppernong, it might be supposed that no fruit could set on the covered clusters as all insects were excluded and it would be impossible for the pollen to get on the stigma, even though the variety might be self-fertile. In 1909, twenty-seven flower clusters of the Scuppernong were bagged, and later, when the flowers had opened, pollen from the James grape was applied to the stigmas; not a single berry set. In 1910, fourteen branches of the Scuppernong containing many flower clusters were similarly covered. Nine of these were carefully hand pollinated with pollen from another portion of the Scuppernong vine, and five with pollen from a James vine. One small seedless berry developed in one bag where the James pollen was applied, and a similar berry where the Scuppernong pollen had been applied. This proves that the pollen from the Scuppernong is ineffective on its pistils. Also that the pollen from the James, typical of other Muscadine varieties now in cultivation, is ineffective on the Scuppernong.

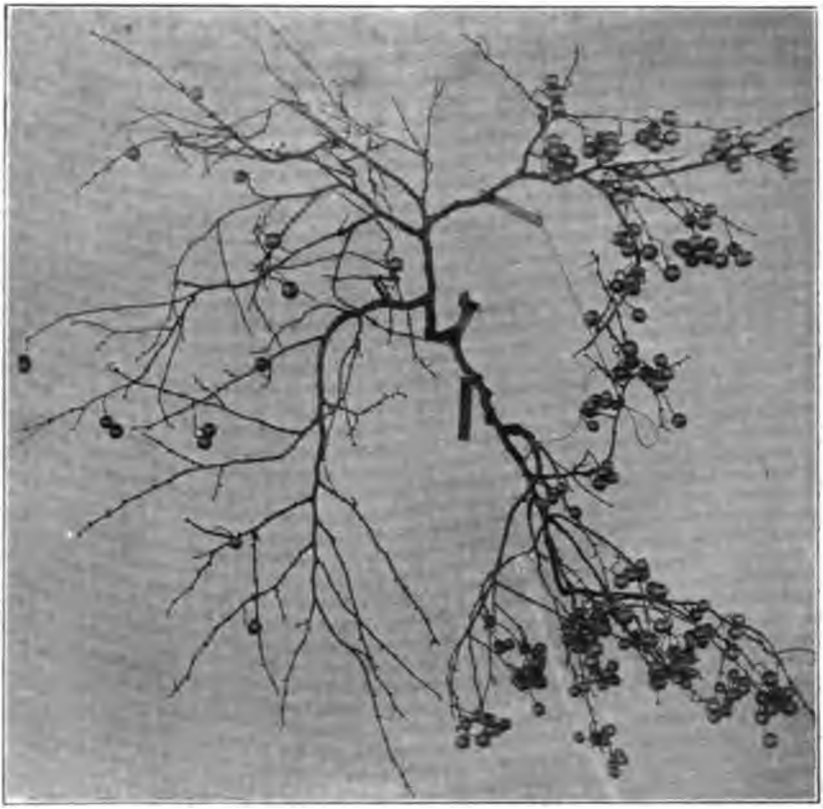


FIG. 5.—Branch of Scuppernong, flowers on right hand pollinated with male pollen, on left untreated. This branch was not covered. 1910, an unfavorable blooming season.

WORK WITH OTHER VARIETIES.

FLOWERS.

During 1908, twenty-five branches on two vines were covered to prevent cross-pollination; no fruit set in any of these bags.

In 1909, seventy-eight branches on two vines were covered; no fruit developed.

In 1910, twenty branches were covered on one vine. Fourteen of these were left untreated, and no fruit set in these bags. The other six bags were opened several times and male pollen applied to the pistils; five of those bags contained well developed clusters of fruit.

JAMES.

In 1908, twenty-six branches were covered on one vine. All of these were left untreated, and no fruit set.

In 1910, eighty-three branches on six vines were covered. Sixty-seven of these were left untreated, and no fruit set. Sixteen were carefully hand-pollinated with male pollen; fourteen of these bags contained good clusters of fruit.

THOMAS.

In 1909, thirty-eight bags were placed on one vine; no male pollen was added and no fruit developed.

In 1910, twenty-six bags were put on one vine. Twenty of these were left untreated, and no fruit set. The other six branches were carefully hand-pollinated with male pollen; five of these bags developed normal clusters of fruit.

MISH.

In 1909, twenty-five bags were put on one vine. No male pollen was added and no fruit set.

Summarizing these results for the Scuppernong, Flowers, James, Thomas, and Mish, we have five hundred and sixty-eight branches, each containing from one to four hundred flower clusters, which were covered to exclude the foreign pollen. In five hundred and fifty-eight of these bags no fruit developed. In eight bags, small, seedless, practically worthless, berries developed. In two bags, a total of two normal berries, and several small worthless, seedless berries developed.

On the Scuppernong, Flowers, James, and Thomas, one hundred and forty-four branches were covered with bags, and later treated with pollen from male vines. Ninety-one of these bags contained well developed fruit, many of these branches being heavily loaded.

GERMINATION TESTS OF POLLEN.

The germinating power and value of grape pollen can be tested in the laboratory. This is done by placing the pollen in cells containing hanging drops of the proper solution. Various solutions are used for testing purposes, but a solution of cane sugar has proved satisfactory with most pollen grains.

In preliminary work, Scuppernong and male pollen were studied in various strengths of cane sugar solution, varying from nothing to forty per cent concentration. It was found that a thirty per cent solution gave by far the best results with the male pollen. The Scuppernong pollen did not germinate in any of these strengths. Pure olive oil was also tried, but neither the male nor the Scuppernong pollen germinated in this.

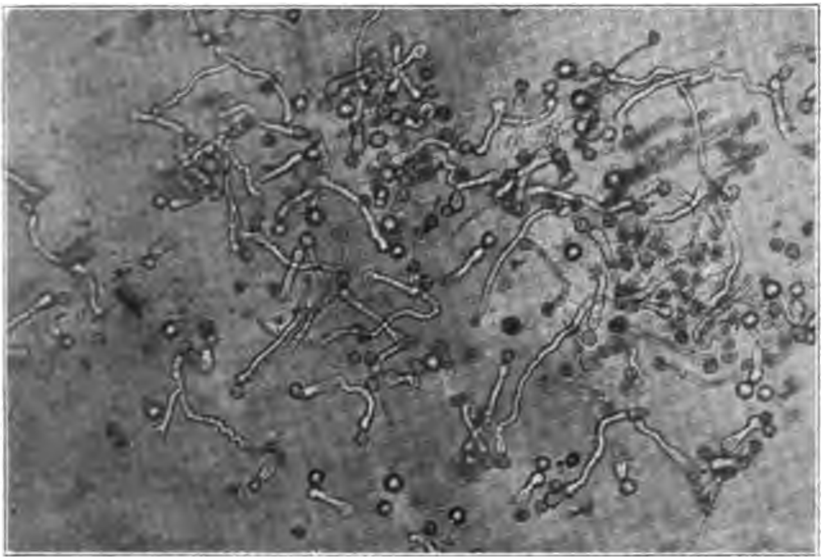


FIG. 6. -Male pollen germinating in sugar solution, after forty-eight hours. (Microphotograph).

After the preliminary tests were made to determine the best strength of solution, extensive tests were made, the results of which are given in the following table:

Variety.	Number of Cells.	Number of Vines Represented.	Germination Per cent.
Scuppernong	435	14	No germination.
James	30	1	No germination.
Flowers	30	1	No germination.
Thomas	25	1	No germination.
Mish	20	2	No germination.
Memory	25	1	No germination.
Flowers Improved	25	1	No germination.
Hopkins	10	1	No germination.
Tenderpulp	10	1	No germination.
Luola	25	1	No germination.
Labama	10	1	No germination.
San Jacinto	10	1	No germination.
San Melaska	10	1	No germination.
Wild Fruiting Muscadines	486	18	No germination.
Male vines	657	5	2–98.

Each cell contained from two hundred to four hundred pollen grains.

The male pollen germinated vigorously in from three to four hours.

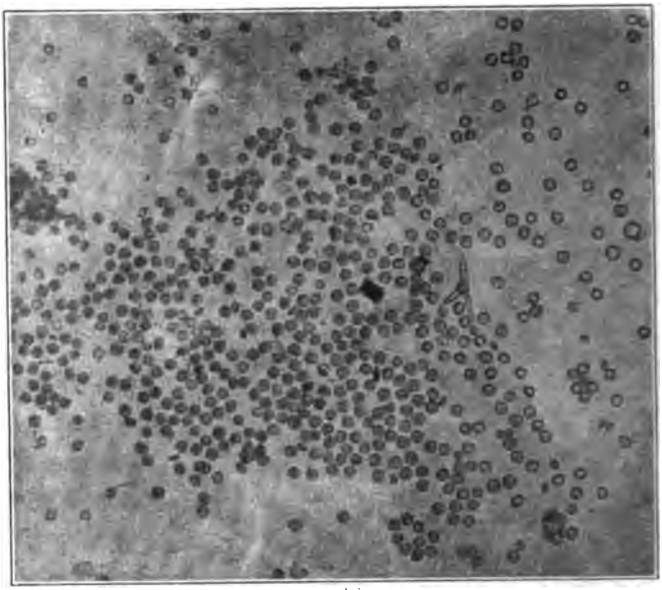


FIG. 7.—Scuppernong pollen in sugar solution after forty-eight hours, showing no germination (Microphotograph).

Not a single pollen grain from any of the cultivated varieties, or fruiting wild Muscadines worked with in this test, germinated.

MICROSCOPIC STUDY OF POLLEN.

A microscopic examination of the dry pollen of these varieties shows why they are self-sterile. The male pollen grains as shown in Fig. 8 are oblong in shape and plump in appearance. Those of the Scuppernong are very irregular and vary a great deal in shape. They appear like mere shells (Fig. 9). The following varieties were examined and all have worthless pollen like that of the Scuppernong: James, Thomas, Mish, Flowers, Memory, Hopkins, Tenderpulp, Flowers Improved, Luola, Labama, San Jacinto, and San Melaska, and a large number of fruit-bearing wild Muscadines.

STRUCTURE OF THE FLOWERS.

The stamens of the male vines are very long, stand upright, and contain a large amount of pollen. The stamens of the Scuppernong are short, recurved or reflexed, and the anthers contain much less pollen than those on the male vines. The flowers on both types are fragrant.

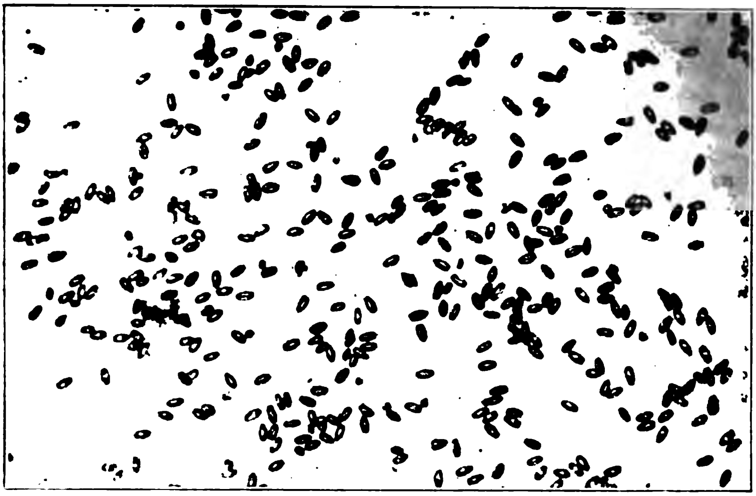


FIG. 8.—Dry male pollen (Microphotograph).

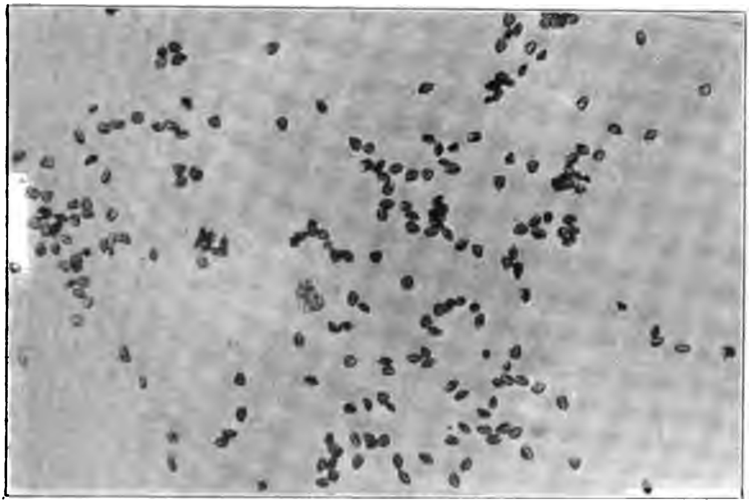


FIG. 9.—Dry Scuppernong pollen (Microphotograph).

The stamens of all the varieties of *Vitis rotundifolia* examined and all except one of the fruiting forms of wild Muscadines are similar to those of the Scuppernong.

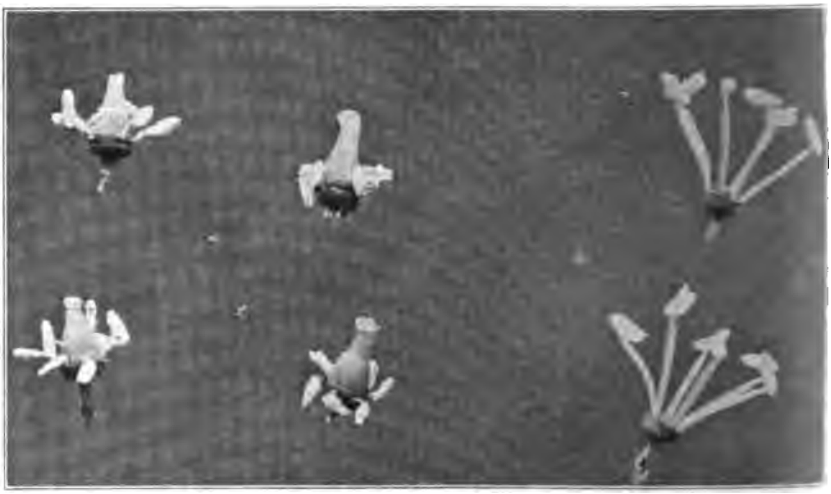


FIG. 10.—Flowers of Scuppernong on left, wild Muscadine in middle, and male on right

NUMBER OF PISTILS THAT DEVELOP INTO FRUIT.

Only a very small proportion of the flowers of the cultivated varieties of this species develop into berries. This accounts for the small clusters. A careful count was taken of all the flowers on a branch. It contained one hundred and twenty flower clusters. The number of flowers in the cluster varied from ten to fifty. The average for the one hundred and twenty clusters was twenty-three flowers to the cluster. The number of clusters that developed berries on this branch was twenty-five. The number of berries to the cluster varied from one to nine, or an average of 2.7. If all the flowers of the Scuppernong developed into fruit, this variety would produce clusters of good size, instead of the small ones which usually contain from one to five berries. As many as sixty flowers have been observed in a cluster of the Scuppernong grape, but the largest number of berries yet found on a single cluster after a careful search of the best vines was twenty-seven.

These figures strongly indicate self-sterility. Usually, most of the flowers fail to get pollinated with pollen from male vines.

The branch mentioned above which contained one hundred and twenty flower clusters, was typical of the remainder of the vine. This branch had a spread of two by two feet. The entire vine covered an arbor thirty-two by forty-four feet. If every flower on this vine had developed into a normal sized berry it would have produced two hundred and nine bushels of fruit, or at the rate of six thousand four hundred and seventy-nine bushels per acre. The largest actual yield of this variety ever authentically reported was at the rate of eight hundred and seventy bushels per acre.

INFLUENCE OF MALE VINES.

The most prolific vines of the varieties studied have usually been found where there were male vines nearby. For example, the vines found within the city of Raleigh are not nearly so prolific as are those in the country or in the outskirts of the city. This is due to the very small number of male vines found in the city. The writers know of two Scuppernong vines in Raleigh, however, which are very prolific. In one instance a male vine is growing on the same arbor with the Scuppernong; in the other the male vine is less than one hundred feet from the Scuppernong vine.

Another good example is a vineyard of James just east of Raleigh. The most prolific vines are found in the two outer rows. There are two male vines on an arbor near one of these rows, and several male vines in the edge of the woods near the row on the other side.

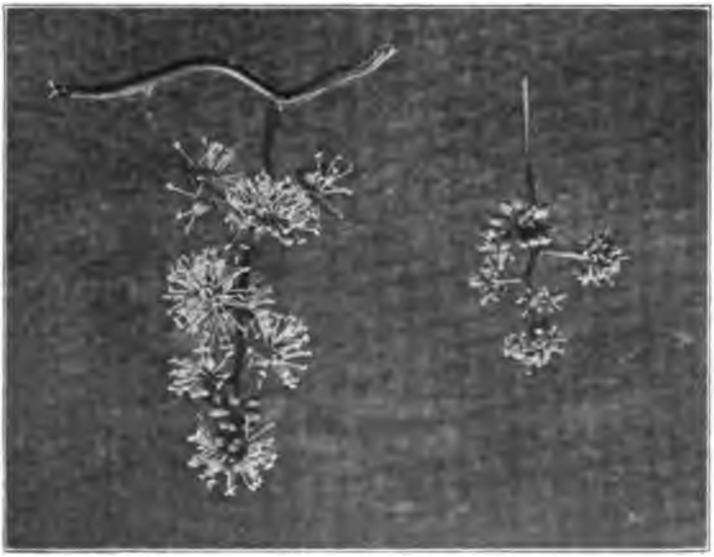


FIG. 11.—Flower cluster of Scuppernong on right, male on left, in bloom.

A careful study was made of the influence that male vines have on the crop in a very large vineyard in the eastern part of the State. The Scuppernong and Mish vines immediately around the male vines were far more prolific than similar vines some distance away, where other conditions were the same, such as age of vines and character of soil. A careful study showed that a Mish vine twenty-five feet from a male vine contained a little more than twice as much fruit as another Mish vine one hundred and fifty feet from this male vine.

In another portion of the vineyard a Mish vine twenty-five feet from another male vine contained three times as much fruit as another Mish vine one hundred and fifty feet away.

A Scuppernong vineyard in which there were male vines contained at least five times as much fruit per vine as another Scuppernong vineyard, on the same farm, in which there were no male vines.

Old neglected vines are sometimes more prolific than well cultivated vines. This is due to the presence of male vines which have come up under the arbor from the seeds of the Scuppernong.

APPARENT EXCEPTIONS.

The writer knows of Scuppernong vines which are long distances from male vines, in some instances as much as a fourth of a mile, which often bear good crops. Such vines indicate that the variety is self-fertile. Two such vines were used in this work, but these proved to be self-sterile just like all the other vines of this variety. A careful study of these vines showed that they produce good crops only when the weather during the blooming season is very favorable to insect work. When the weather is rainy and cloudy during the blooming season such vines produce very small crops.

Furthermore, since the blooming season of each variety covers two to four weeks, and since an enormous crop of flowers is usually produced, the chances are that insects will carry enough pollen long distances during favorable seasons to insure a fair crop of fruit.

AN EXCEPTIONAL VINE.

During the summer of 1910 an exceptional wild Muscadine vine was found about one mile from the Station grounds. It is a fruiting vine, with a very large number of pistils in each flower cluster, many clusters containing from one hundred to one hundred and fifty pistils. It is distinct from all other fruiting vines examined in that the stamens are like those on the male vines; that is, long, upright, with an abundance of good fertile pollen. Pollen from this vine placed in a sugar solution germinated readily, at least ninety-five per cent of the pollen grains in each cell germinating. While there are a great many pistils in each flower cluster, these pistils are very small in size, and the clusters of fruit are no larger than those on the self-sterile wild vines. This vine was found late in the season and our work with it has been too limited to draw any conclusions.

ABUNDANCE OF MALE VINES.

Wild Muscadine vines are very abundant all through the eastern half of this State. They are found in forests, along streams, roads, in hedge rows, in blackberry and plum thickets, and along neglected fences. At least seventy-five per cent of these are male vines. This explains why the cultivated Muscadines often bear abundantly, although male vines may never have been planted in the vineyard.

RESULTS.

The results obtained indicate conclusively that the leading varieties of cultivated Muscadine grapes are self-sterile. Also that practically all of the perfect flowered wild Muscadine grapes are self-sterile. While we have vines of all of T. V. Munson's hybrids of this species, only three of these have bloomed, and these have proved self-sterile. Munson states that the others also are self-sterile.

APPLICATION OF RESULTS

Since the cultivated varieties of this species are self-sterile, provision should be made for cross-pollinating them. Where such varieties are growing near wild male vines a fair crop may be obtained without planting any male vines. But to insure largest yields, male vines should always be planted with these varieties. This is a rather expensive practice, as the male vines must be given space and cared for, although they do not bear any fruit themselves. The value of male vines in the vineyard will be most apparent during unfavorable

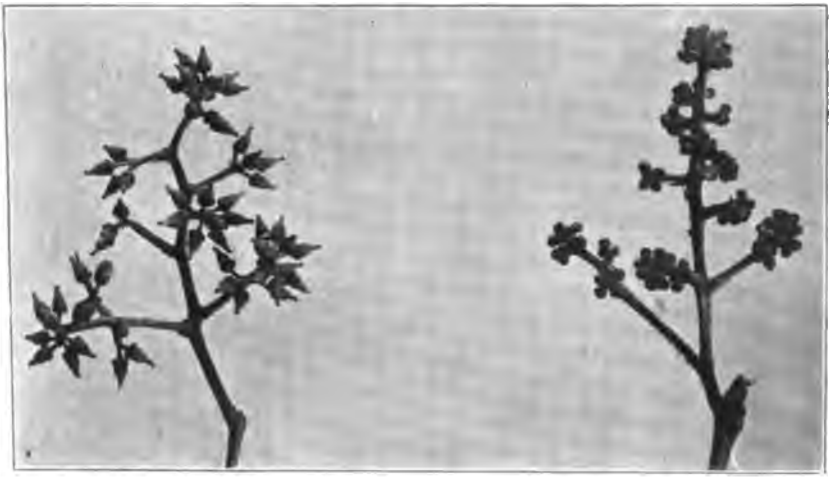


FIG. 12.—Clusters showing pistils of Scuppernong on left: imperfect pistils of male on right.

seasons. The question, whether cultivated varieties of other spe can be used as pollinizers, will probably be asked. Up to the pres time no varieties have been brought into cultivation that will ser this useful purpose. The blooming season of the Muscadine gra is much later and lasts much longer than that of any self-fer species.

It is impossible to state what proportion of a vineyard should male vines. For best results it seems that a male vine should planted for every fruiting vine and trained on the same arbor. Th would certainly insure the largest crop. Such proximity of m vines would be especially serviceable during rainy weather when i sects are not very active. The two vines would intermingle on t arbor, and the male flowers and fruiting flowers would be nearer e other than in any other method of planting.

But there are objections to this method of planting. Unless sy tematically pruned, the male vines will tend to make the arbor mo dense and increase the amount of shade, both of which conditi are serious hindrances to the insects that carry the pollen. Th double growth of vines would also increase the difficulties in prun and in harvesting the fruit.

The most satisfactory plan probably would be to plant male vi in every third row, and to have only every third plant in this r a male vine. This would give one male plant for every eight fru ing plants, and these fruiting plants would be well grouped aro the male vines. The following sketch, in which circles indica fruiting vines and the crosses male vines, illustrates this method o planting:

O O O O O O

O X O O X O

O O O O O O

O O O O O O

O X O O X O

O O O O O O

KIND OF MALE VINES TO PLANT.

There is great variation in male vines. Some are very heavy bloomers, producing a great number of flower clusters of large size and hence an abundance of pollen, while other vines produce few flower clusters, often of small size, and hence comparatively little pollen. Some male vines bloom early, others late. Some have a long blooming season, while others bloom for only a short time. Fig. 13 shows the variation in the size of the flower clusters, and hence the amount of pollen produced.

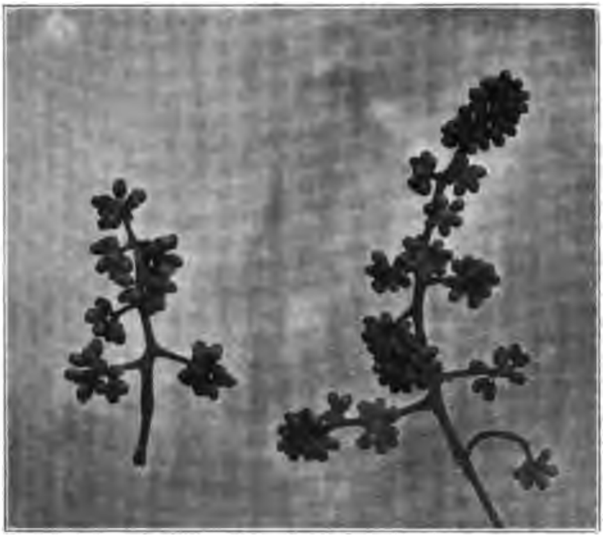


FIG. 13.—Male flower clusters in bud. One on left showing size from an average vine; the one on right, size from an exceptional vine.

The cultivated varieties of Muscadine grapes also have a long blooming season; and some varieties bloom considerably earlier than others. This emphasizes the necessity of planting not simply male vines, but the right kind of male vines.

Varieties that bloom early, like the Hopkins, and Memory, should have early blooming male vines planted with them. Varieties that bloom during mid-season, like Scuppernong, James, Mish, Thomas, and Tenderpulp, should be planted with male vines blooming at that time. The late blooming varieties like Flowers, Flowers Improved, and Luola require late blooming male vines.

Nurserymen who sell varieties of this species should also propagate male vines which will correspond in blooming season with the particular varieties they are selling.

WEATHER DURING BLOOMING SEASON.

The entire blooming season of all varieties extends from the middle of May until the last of June. During that season the weather should be warm, with an abundance of sunshine and comparatively few showers. During such weather insects are most active, the pollen is in good condition, and fertilization takes place readily. The crop fails oftener from continued rains during the blooming season than from any other cause. Growers know that a wet June always means a poor crop of Muscadine grapes. Where male vines are abundant, wet weather during the blooming season is the only cause of a general crop failure among Muscadine grapes.

WORK OF INSECTS.

The pollen is carried from the male vines to the fruiting vines by insects, the most important of which are honey bees, and various flies. But these insects are not nearly so abundant nor so active on this species of grapes as they are on many other plants. This fact probably more than anything else accounts for the small proportion of flowers that develop into fruit. This probably explains why nature has provided such a large proportion of male vines. For this reason the writer recommends a larger proportion of male plants than is usually recommended for other self-sterile plants.

Every effort should be made to encourage bees. It is very evident from our results that at least one hive of bees should be kept where any large number of vines are grown.

SELF-STERILITY NOT ALWAYS RESPONSIBLE.

Self-sterility is not responsible for all poor crops. Even where male vines are abundant a vine may not produce a large crop. If the vines are very heavily fertilized with nitrogenous materials without a corresponding amount of potash and phosphoric acid, there will be a very rank growth of vines at the expense of fruit. Heavy clay soil is not suited to Muscadine grapes and the crop is usually light on such soils. Low, moist, black loam soil also produces a very rank growth and a small crop of fruit. Vines on very poor soil, unless liberally supplied with manure and commercial fertilizer, will usually give small crops of fruit. Where vines become badly affected with Black Rot the crop is materially reduced.

VALUE OF PRUNING.

One of the chief hindrances to proper cross-pollination is the very heavy growth of vines on many arbors, some of the old vines forming dense mats more than a foot thick. It is difficult for insects to get to many of the flower clusters in such compact growths, hence cross-pollination is almost entirely prevented. This emphasizes the necessity of proper pruning and thinning of the vines so that insects can readily get to all the flowers. The vines should be systematically pruned every year during November. Such pruning seems to have a marked effect in increasing the size of the fruit clusters.

GROWING PLANTS FROM SEEDS.

One of the most interesting things that has developed in our work is the character of the seedlings grown from seeds of the Scuppernong. It is generally known that the seedlings of the Scuppernong in nearly every instance produce dark fruit, while the Scuppernong bears light-colored fruit. If the Scuppernong were self-fertile this probably would not happen. There are two types of male vines. On one, which resembles the Scuppernong, the leaves, young shoots, nodes, and tendrils are light or greenish in color. The other type, which resembles in vine characteristics the varieties bearing dark fruit, has dark leaves, and reddish tendrils, nodes, and shoots. In our first two years' work pollen from a "light" male vine only was used on the Scuppernong. The seeds were saved and planted. Every resulting seedling is "light" in color; and most of those having female flowers will produce light colored fruit.

The "light" male vines are very rare; we have found only six such vines after careful searching. The dark male vines are very abundant; and this explains why such a large proportion of the seedlings produce dark fruit where insects carry the pollen.

This fact will be of great value to grape breeders in the South, as the seedlings of the Scuppernong can be made to produce either dark or light colored fruit by selecting, in making the crosses, pollen from either the dark or light male vines.

BULLETIN 210 SEPTEMBER, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

IMPROVED METHODS FOR MAKING COTTAGE AND NEUFCHATEL CHEESE

Edwards & Broughton Printing Co.,
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh
E. M. KOONCE	Jacksonville
T. W. BLOUNT	Roper
D. A. TOMPKINS	Charlotte
J. T. ELLINGTON	Smithfield
W. E. DANIEL	Weldon
W. H. RAGAN	High Point
W. B. COOPER	Wilmington
M. B. STICKLEY	Concord
T. T. BALLENGER	Tryon
N. B. BROUGHTON	Raleigh
O. L. CLARK	Clarkton
EVERETT THOMPSON	Elizabeth City
R. H. RICKS	Rocky Mount
O. MAX GARDNER	Shelby
M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
JOHN MICHELS	Dairy Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. D. CECIL	Animal Pathologist
J. G. HALL	Assistant in Plant Diseases
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
P. L. GAINEY	Assistant Bacteriologist
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

	PAGE.
Pure Cultures of Lactic Acid Bacteria	29
Making Cottage Cheese	29
Souring the Skimmilk	29
Cutting the Curd	31
Heating the Curd	31
Draining the Curd	31
Salting	32
Soaking	32
Packages and Packing	32
Cream Cottage Cheese	33
Yield of Cheese	33
Marketing	33
Serving Cottage Cheese	33
Cottage Cheese as a Food	33
Neufchatel Method	33
Improved Method of Making American Neufchatel Cheese	34
Making Neufchatel Cheese—	
Kind of Milk	34
Equipment	34
Ripening the Milk	34
Adding Starter	35
Setting the Milk	35
Cutting the Curd	35
Draining the Curd	36
Salting	37
Mashing the Curd	37
Packing	37
Packing in Tumblers	37
General Pointers	38
Selling Price	38
Yield	38

IMPROVED METHODS FOR MAKING COTTAGE AND NEUFCHATEL CHEESE.

By John Michels.

PURE CULTURES OF LACTIC ACID BACTERIA.

In making Cottage and Neufchatel cheese, the first and most important essential is good flavor. Next in importance is uniformity of product. Both of these essentials can be obtained with certainty only by the use of pure cultures of lactic acid bacteria in souring the milk.

The cultures containing the lactic acid ferment are prepared commercially, and small samples, either in dry or liquid form, can be obtained from manufacturers at about seventy-five cents per bottle. The bottle thus obtained is emptied into a quart of pasteurized skimmilk, that is, skimmilk which has been kept at a temperature of about 170° F. for thirty minutes and then quickly cooled to about 70° F. As soon as the quart of skimmilk has thickened, which usually requires about twenty-four hours, it is ready for use.

In the process of heating, all of the active bacteria in the skimmilk are destroyed, thus leaving a clean field for the development of the lactic acid bacteria added to it from the bottle.

The method of using the lactic acid bacteria is similar to the use of yeast in breadmaking. The original germs obtained from the manufacturer may be propagated for weeks by daily transferring a small amount of the thickened skimmilk to newly pasteurized skimmilk. As a rule, one pound of the thickened skimmilk will sour thirty to forty pounds of sweet pasteurized skimmilk in twenty-four hours at a temperature of 70° F.

Parenthetically, it may be stated that pure culture of lactic acid bacteria (starters) are also frequently used in souring cream for buttermaking. Indeed, the highest quality of butter is not possible without their use.

MAKING COTTAGE CHEESE.

Hitherto no definite method has been employed in the making of Cottage cheese, which, no doubt, is largely due to the fact that its manufacture has been almost entirely confined to the home. The method in common use, consists essentially in placing curdled milk, either heated or unheated, in a linen or cotton cloth bag which is hung up in some convenient place to allow the curd to drain.

Where cheese is to be made on a commercial scale, this method has not been found satisfactory. After much experimentation, we have succeeded in developing a method which has proven perfectly satisfactory in making cheese for city trade, and which it is felt can confidently be recommended for use by dairymen in general. The successive steps in this process are described in the paragraphs following.

Souring the Skimmilk.—Where from ten to twenty pounds of cheese are to be made at one time, the skimmilk is most satisfactorily soured in four to eight gallon shotgun cans which have a uniform diameter of from eight to ten inches. Enough pure culture of lactic acid ferment is added to sour the skimmilk in about three hours at a temperature of 100° F. As a rule, one gallon of culture to every four gallons of sweet skimmilk will accomplish the souring in the given time.

The culture should be vigorously stirred and then thoroughly mixed with the skimmilk. As soon as this has been done the cans containing the mixture are placed in a tank of water, as shown in Fig. 1. In heating the skimmilk to 100° F. the water in the tank should never exceed 110° F. The high temperature employed in souring the skimmilk has several advantages: (1) it hastens the souring process; (2) it causes the skimmilk to curdle with less acid, thus making a milder cheese; and (3) the curd may be stirred as soon as curdled without danger of diminishing the yield.

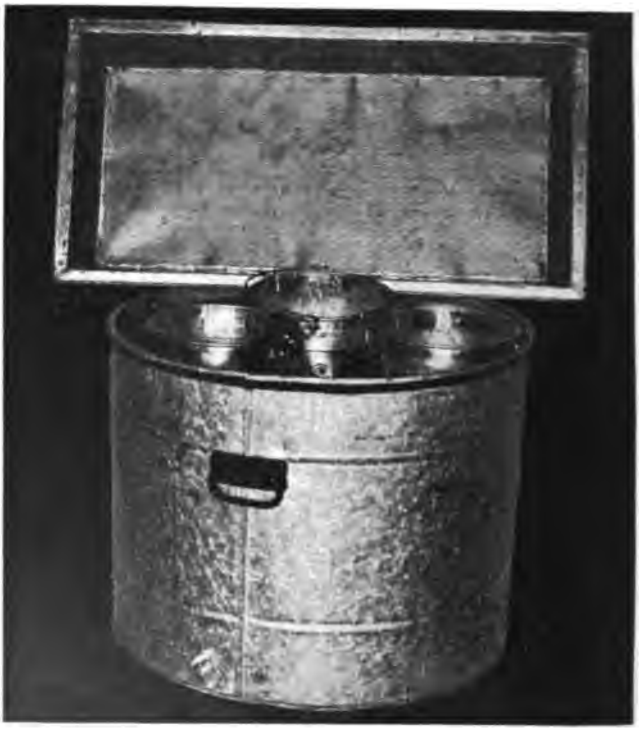


FIG. 1.—Strainer and Shotgun Cans in Water Tank.

Where large quantities of cheese are to be made, the skimmilk should be soured in a common cream vat with an open end, which is usually used for adding ice to the water underneath. In the manufacture of Cottage cheese, this open end is necessary in order to observe the temperature of the water used in heating the milk and curd.

Cutting the Curd.—After the milk has thoroughly thickened, it should be broken up, with a knife preferably. Knives used for Cheddar cheese making are best. Where small quantities of cheese are made, a stirring rod like that described below will break up the curd satisfactorily.

Heating the Curd.—As soon as the skimmilk has thoroughly curdled, the curd should be raised to a temperature of 104° F. by heating the water surrounding the curd to about 115° F., and care should be taken never to heat it above 120° F. During the heating the curd should be constantly stirred with a stirrer consisting of a four-inch heavy tin disc attached to an iron rod. Where a cream vat is used, the stirring is done by hand. When the curd has reached a temperature of 104°F. the water surrounding it should be removed and the stirring continued at intervals for forty minutes more, after which it is ready to drain.

In case the curd seems unusually soft, as is not infrequently the case, it will be an advantage to heat as high as 108° F. However, care must be taken when high temperatures are employed as they are apt to result in a tough curd.

Draining the Curd.—This is best accomplished in a tin strainer with perforated sides and bottom like that shown in Figs. 1 and 2. The strainer should be of ample size to hold conveniently all the curd, and to expedite drainage. A piece of cheese cloth should be spread over the strainer before receiving the curd. The latter must be hand-stirred as soon as it reaches the strainer, but the stirring should be done very carefully at the start to avoid loss by mashing the particles. Continue the operation until the curd is firm enough to prevent the particles from sticking together, which usually requires about five minutes. When proper firmness is reached, the curd is wrapped in the cloth strainer and squeezed with the hands until most of the whey has been removed. This operation requires only a few minutes, and care must be taken not to press the curd too hard. After pressing, the curd appears in a roll like that shown in Fig. 2.

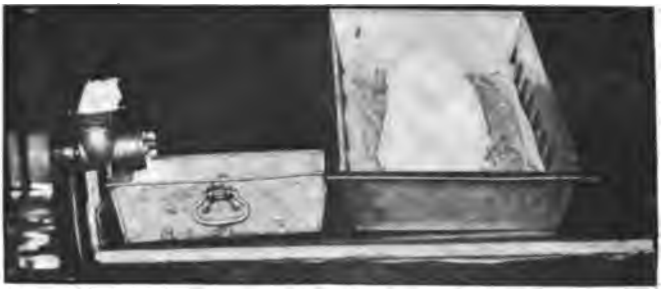


FIG. 2.—Curd in Strainer after pressing, and Curd Grinder.

Originally it was found necessary to grind the curd after pressing. This operation may be eliminated, however, by sqeezing the curd until it can be readily granulated (without stickiness) with the hands. A little too much moisture is indicated by toughness and stickiness of the curd. Further squeezing will rectify the trouble. On the other hand it is important not to get the curd too dry, though it is possible to overcome this by more soaking with milk or cream which will replace the extra moisture lost.

Salting.—When the curd has been squeezed dry enough, and is thoroughly granulated by rubbing and mixing with the hands, salt should be added at the rate of about one ounce per 6 to 8 pounds of cheese. Carefully mix the salt and curd and then proceed to soak the curd with milk or cream.

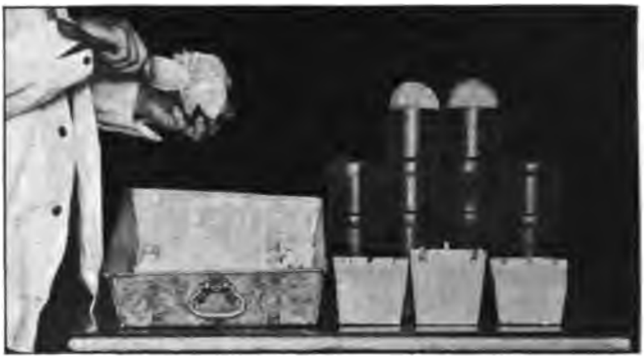


FIG. 3.—Cottage Cheese Packages and method of filling them.

Soaking.—Now soak the curd with sweet, preferably pasteurized milk, until the curd assumes a moist condition. The amount of milk required for this purpose varies from one and one-half to two quarts for every ten gallons of skimmilk used. Two-thirds of this should be added immediately after salting, after which the curd is set aside for at least ten minutes when the soaking may be completed.

The amount of milk to be added to the curd varies somewhat from day to day, depending upon the amount of moisture left in it before salting. The rule to follow is to leave the curd fairly wet, but not so wet as to have the milk drip from it. If the cheese is to be kept a number of days, it is best to leave it rather dry by soaking less.

Packages and Packing.—Among a number of styles of packages tried, two have proven satisfactory: namely, the Gem Fibre butter package, made of pasteboard and lined with parchment paper; and a water-proof paper package commonly used for carrying ice cream. Both of these packages are illustrated in Fig. 3. The round packages are the Gem Fibre, which are easier to pack and better liked by consumers, though the cost is somewhat more than the water-proof paper sacks. It was found best to line both packages with parchment paper which has been either boiled in water or soaked in strong salt brine. Any surplus moisture should be allowed to drip from the paper before putting it into the packages. The latter should be washed in clear water before using, to insure freedom from dust.

Where cheese is to be kept a week or longer before it is consumed, tin capped glass tumblers have proven the most satisfactory packages, though more expensive than the other packages mentioned. A paraffined or parchment cap should be put under the tin cover. Both tumbler and parchment cap should be sterilized in hot water before using.

The cheese is put into the packages by means of a large spoon, in the manner shown in Fig. 3.

Cream Cottage Cheese.—A high quality of cheese is secured by soaking the curd with cream instead of milk. Many customers will gladly pay the increase in the price necessitated by the addition of cream instead of milk. The cream cottage cheese is preferably packed in tumblers.

Yield of Cheese.—The average amount of skimmilk required to make a pound of cheese soaked with milk is 7.1 pounds. Soaking with cream increases the yield.

MARKETING.

The writer has sold large quantities of this cheese to grocers at ten cents per pound, the latter retailing the same at fifteen cents per pound. The grocers were supplied with attractive signs calling attention to the fact that they had the cheese for sale.

Cottage cheese should be kept at reasonably low temperatures if desired to keep for some time. At refrigerator temperature it may be kept satisfactorily for several days when packed in pasteboard packages. If packed in tumblers as previously explained, it will keep several weeks at such temperatures.

The most satisfactory way of disposing of the Cottage cheese is to sell it direct to milk and cream customers along the route daily traveled by the dairyman. This saves the middleman's profits and insures the delivery of the product fresh.

SERVING COTTAGE CHEESE.

When the cheese is made according to the writer's method, it may be served without further treatment. Its palatability, however, may be improved by the addition of cream, especially when no cream was used in its manufacture. Additional salt and some pepper is also preferred by some. Others prefer adding sugar or syrup. Caraway and sage are sometimes used to flavor the cheese.

COTTAGE CHEESE AS A FOOD.

Cottage cheese when made as herein described, not only has a high food value, but has also tonic or medicinal qualities which are especially valuable during warm weather. Its nutritive value, where no cream is used is about the same as that of beefsteak. When soaked with cream it has a higher food value.

NEUFCHATEL METHOD.

Cottage cheese may also be made by the same method outlined in the following pages for Neufchatel cheese. The principal objection to this method is that the cheese is apt to get too dry, especially when made in small quantity. When made in large quantity, the method will prove satisfactory.

IMPROVED METHOD OF MARKETING AMERICAN NEUFCHATEL CHEESE.

During the past year, the Dairy Division of the Station has carried out extensive experiments in the manufacture of American Neufchatel cheese. The method hitherto employed in the manufacture of this cheese has not been entirely satisfactory. The process has been too long drawn out and too little attention has been given to the control of the lactic fermentation or souring process. In consequence of this the cheese has seriously lacked in uniformity, a very essential quality in any dairy product. Furthermore the packages in which the cheese has heretofore been sold have not been sufficiently tight to give the cheese a high degree of keeping quality. Very little of this cheese can be bought in the market during the summer owing to its poor keeping qualities.

In our experiments we have succeeded in overcoming almost entirely the objections above mentioned and the details of the process as worked out by us will be given now in detail.

MAKING NEUFCHATEL CHEESE.

Kind of Milk.—Whole milk reinforced with an amount of cream equal to about one-quarter that in the whole milk makes the best Neufchatel cheese. However, whole milk without the addition of cream will make a very satisfactory cheese. It is of first importance to use only milk which is clean and free from taints.

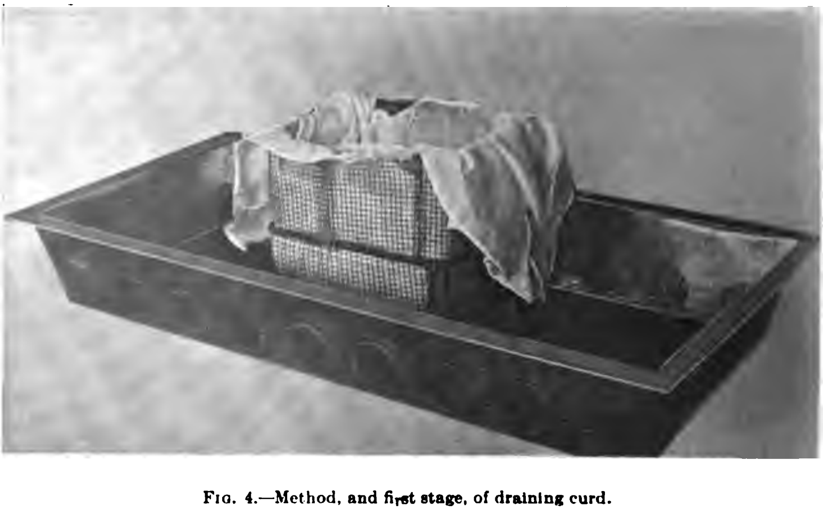


FIG. 4.—Method, and first stage, of draining curd.

Equipment.—When the cheese is made on a small scale, common cans of the shotgun style will answer for handling the milk. Where several hundred pounds of milk are used a small milk or cream vat may be used. A strainer with perforated sides and bottom is also needed to drain the curd.

Ripening the Milk.—As in the manufacture of Cottage cheese, the milk should be treated with a large amount of starter, or pure culture of lactic acid bacteria. On an average, one pound of starter to four pounds of milk will give best results. During warm weather when the milk has already ripened somewhat, and when there naturally is a more rapid development of actic acid, one part of starter to five of milk will be about right. On the other hand, during cold weather or when the milk is very sweet, it is best to use at the rate of one part starter to three parts of milk.

Adding Starter.—Thoroughly beat or shake the starter and strain it through one thickness of cheese cloth before adding it to the milk.

Setting the Milk.—As soon as the starter has been added, heat the milk to 80° F. and add at the rate of 2½ ounces of commercial rennet extract per 1000 pounds of milk. The rennet extract should be diluted with water to the extent of about eight times its own volume and then thoroughly mixed with the milk. The mixing should not be continued for more than three minutes. This precaution is necessary as the milk begins to thicken in about five minutes. Cover the milk and allow it to stand quietly for thirty to sixty minutes according to the amount of starter used. The more starter used the quicker the milk will curdle.

Cutting the Curd.—While the milk will usually be ready to cut in from thirty to sixty minutes, it is best to determine when this point is reached as for Cheddar cheese, by breaking the curd with the forefinger. If the whey in the break is clear, the curd is ready to cut; if milky, the curdling has not progressed far enough. In general the curd should be somewhat firmer than for Cheddar cheese before cutting.

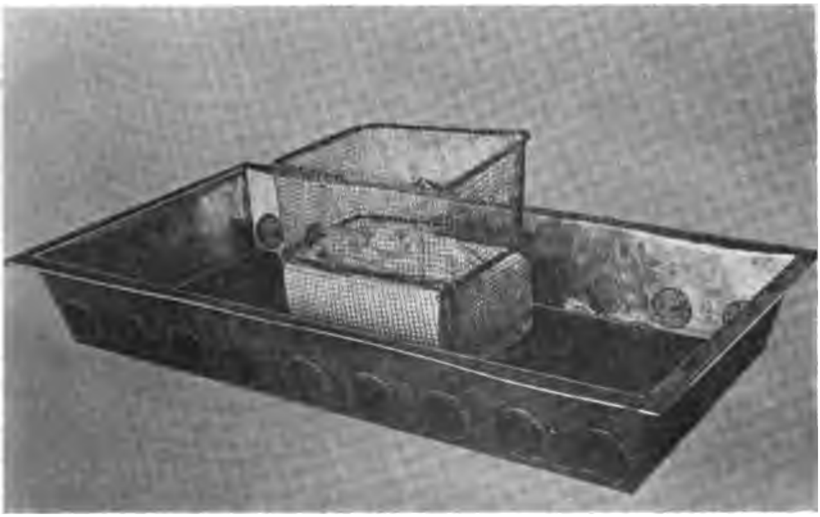


FIG. 5.—Curd after draining for an hour.

Where much cheese is made, the curd is cut with special knives used with Cheddar cheese. The cutting in this case is done as follows: First cut the curd in horizontal layers with the horizontal knife; next cut lengthwise, and then crosswise with a perpendicular knife. This will make cubes about one-half inch on a side. Where small quantities of cheese are made any kind of a knife may be used to cut the curd. The smaller the amount of milk used, the coarser the curd should be cut.

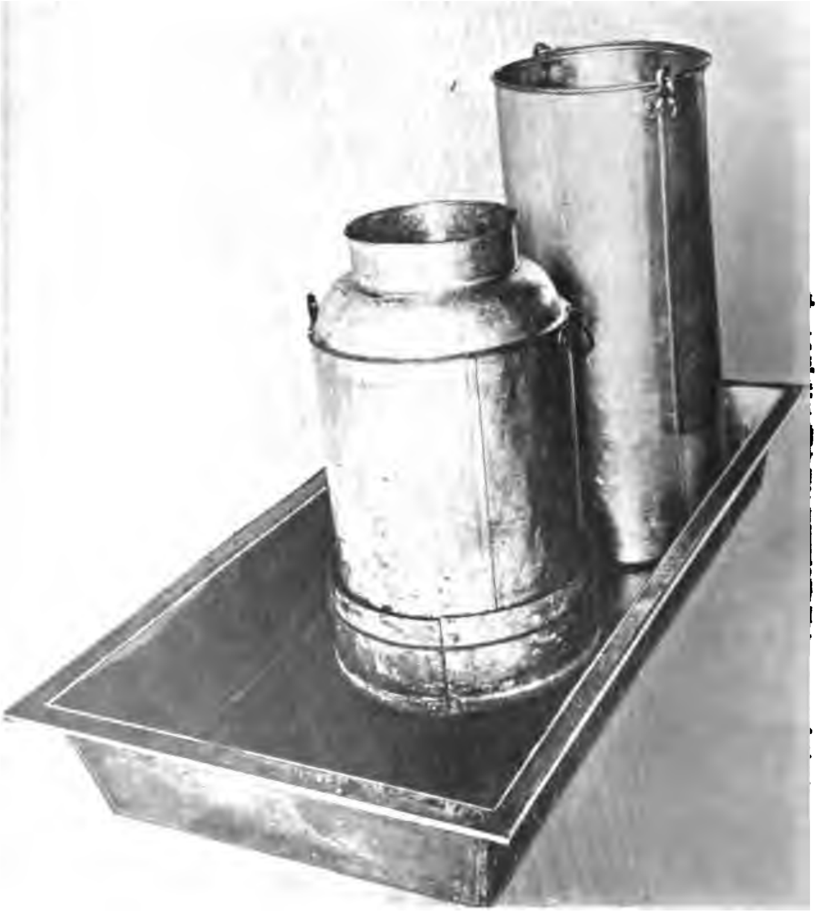


FIG. 6.—Pressure on the curd furnished by cans of water.

Draining the Curd.—As soon as the curd is cut it is carefully poured into a tin strainer lined with one thickness of cheese cloth. Both the sides and bottom of the strainer should be perforated. It should be about ten inches deep and of such width and length as to permit filling it the full depth. Allow the curd to drain undisturbed for about one hour and then put a cover, preferably a metallic one, on it and add pressure at the rate of one pound for every gallon of milk used. During the next hour gradually increase this pressure until five pounds are used for every gallon of milk. Continue this amount of pressure for eight hours and then reduce to two pounds for every gallon of milk and keep at this pressure twelve hours longer when the curd is ready to salt.

Salting.—Salt at the rate of about one ounce of salt to six pounds of cheese. The salt can be evenly distributed during the mashing process.

Mashing the Curd.—With a heavy masher similar to a potato masher, thoroughly mash the curd to a smooth consistency, leaving no unbroken particles or lumps. The smoother the curd the richer it will appear and the better it will taste.

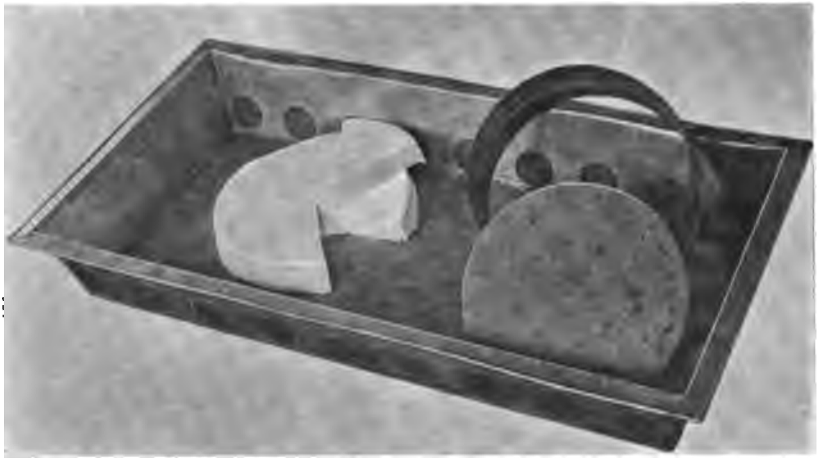


FIG. 7.—Consistency of curd after being pressed.

Packing.—A variety of packages may be used in which to pack the cheese. The common method of packing is to first wrap the cheese in parchment paper and then in tin foil. This method of packing is especially suitable where cheese is made on a small scale. Such a package is open to the objection, however, that it does not sufficiently exclude the air to prevent molding.

The best package is one in which the cheese can be kept as nearly air-tight as possible. We have found a tin capped tumbler the most satisfactory. The only objection to the tumbler is the expense when purchased in small quantities. In large quantities 8 ounce tumblers may be purchased very cheaply.

PACKING IN TUMBLERS.

A large spoon furnishes the best means for packing cheese in tumblers. The tumblers and the parchment caps which are put under the tin caps should be sterilized in boiling water before using. Pack the tumbler brim full, then place a parchment paper cap on top and then cover with tin cap. The parchment cap should project about one-quarter inch over the edge of the tumbler. Cheese packed in this way will keep 10 days during warm weather without refrigeration.

GENERAL POINTERS.

In making Neufchatel cheese as herein described a good starter is indispensable. It will pay well to give the starter careful attention. Use attractive labels on the tumblers. They cost little, but will help sell the cheese at a better price. While the cheese can be kept some time without refrigeration, it is best to keep it in as cool a place as possible, such as a cellar.

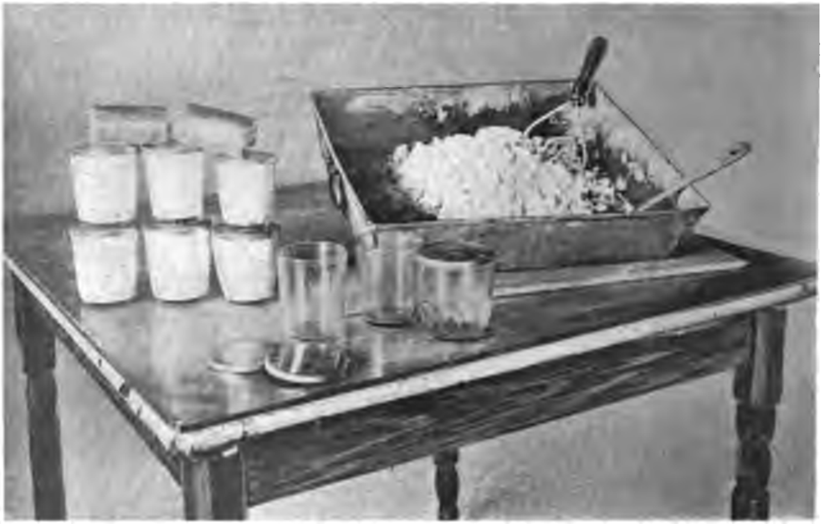


FIG. 8.—Curd ready to pack in two styles of packages.

SELLING PRICE.

Cheese packed in 8-ounce tumblers should readily sell at 10 cents per tumbler net. This price will yield good returns for milk and furnishes the consumer a wholesome and digestible food at a very reasonable price. In fact, cheese at the price mentioned, will be cheaper than meat at prevailing prices, especially when total digestible nutrients are considered.

YIELD.

Cheese made from 4 per cent. milk will yield thirty-four 8 ounce tumblers of cheese per hundred pounds of milk. When such milk is reinforced with an additional pound of butter-fat in the form of cream, the yield will be thirty-eight tumblers of cheese.

BULLETIN 211 SEPTEMBER, 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

FEEDING AND MANAGEMENT OF POULTRY FOR EGG PRODUCTION

Edwards & Broughton Printing Co.,
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLENGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. C. MCNUTT	Dairy Husbandman
J. D. CECIL	Animal Pathologist
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
T. B. STANSEL	Assistant Bacteriologist
GUY WEST WILSON	Assistant in Plant Diseases
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS

	PAGE.
Introduction	43
Requisites for profitable egg production	43
The stock	43
Necessity for and indications of vigor	43
Breeding for egg production	45
Points to be considered in selecting breeders	45
Trap nests	46
Poultry houses	46
Conditions necessary for a good house	47
Wire front houses	47
Food requirements of the hen	49
Composition of the hen	49
Composition of an egg	49
Functions of different food elements	49
Sources of supply of different food elements	50
What constitutes a good ration	50
Grains used in feeding experiments	51
Products used to supply protein and ash	51
Method of feeding	52
The advantage of the dry mash	52
Feed boxes for the dry mash	53
Fowls used	54
Rations used	54
Yard conditions	55
Cost of feeds used	55
Cost of feeding on different rations	56
A comparision of highest and lowest cost ration	56
Rations fed to pens 1 and 2 and results obtained	56
A comparison of ration fed to pens 12 and 13, and that fed to pens 14 and 15	57
Comparative cost of feeding on cottonseed meal ration and meat meal ration	57
Results of feeding experiments for second period	58
A comparison of these results during first and second periods	58
Summary of results on different rations	59
A comparison of results from pens 15 and 20, and 24 and 25 during first and second periods	61
Necessity for cleanliness	62
Connection between filth and mites	62
Method of killing mites	62
How to make kerosene emulsion	62
Insect powders	63
Conclusions	63

FEEDING AND MANAGEMENT OF POULTRY FOR EGG PRODUCTION

BY J. S. JEFFREY.

The production of eggs for market is generally considered the most profitable branch of poultry keeping.

Under proper conditions there is no reason why eggs should not be produced at a price that will allow a good margin of profit. This should be especially true of eggs produced on farms where the fowls may find a large part of their sustenance at no cost to the farmer, utilizing what would otherwise be waste products.

With a knowledge of what is necessary for the best results in egg production, the farmer should be able to supplement the natural resources of the farm in such a way that revenue from the hens would be largely increased by a small extra outlay for food.

The profitable production of eggs depends on several different conditions, any one of which being wrong may seriously handicap one's efforts for the production of eggs at a profit.

The stock which is to lay the eggs must be of the right kind and of suitable age. Comfortable houses must be provided to protect the stock from the wet and wind.

Proper food must be supplied in some way that is suited to the needs of the hens, and which does not call for too much labor on the part of the poultryman in its preparation and feeding.

All of these are important and necessary if the best results are to be obtained, but they will not bring success unless the houses are kept clean and free from mites.

STOCK

In considering the question of stock, it can be done without taking special account of the different breeds, as good layers may be found in almost any breed.

It is necessary, however, that the fowls of whatever breed have strong constitutions. A hen that lacks in vitality will never make a good layer or a breeder of good laying stock. If strength and vigor are lacking in the stock, failure is sure.

Fowls can be selected for strength and vitality very largely by their appearance and condition. The active, sprightly bird is likely to be strong. The hen that is first off the roost in the morning, always on the move, hunting for food, and the last to go to roost at night, is not apt to be a weakling. On the other hand, the hen that comes off the roost when you feed in the morning and sometimes goes back there after feeding, that does not care to scratch or forage for food, is likely to be a weakling and on that account should be discarded as a breeder.

The male should be gallant, always on the move, looking after the hens and calling them when he finds anything especially tempting. He should have a loud, strong crow and should be masculine in appearance and carriage. Figs. 1 and 2 show birds of good vigor.

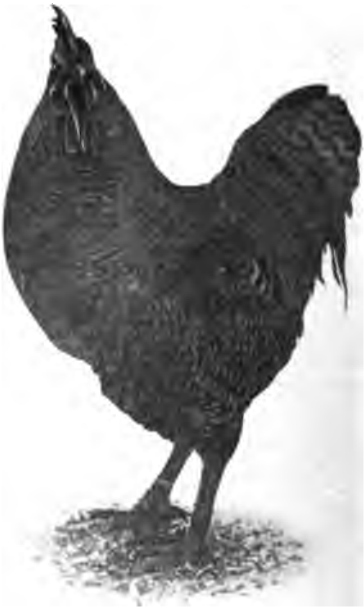


FIG. 1—A good vigorous Barred Plymouth Rock Cockerel.

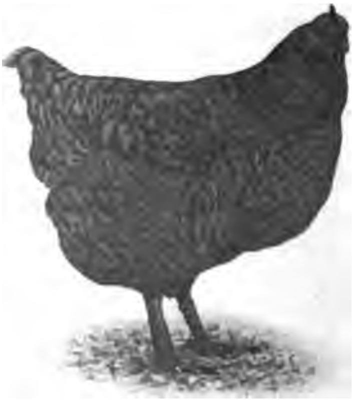


FIG. 2—A Barred Plymouth Rock hen of good type.

If stock of this kind is selected, the chances of success are much greater than they would be with stock bred from the very best layers that lacked in stamina and vigor.

A great deal has been written in regard to breeding up a heavy laying strain, and according to some it is one of the most simple problems that the poultryman has to solve. According to this class of writers, all that is necessary is to use trap nests to get the records of the different hens, select the heaviest layers as breeders, and success is assured. If this is true, heavy laying should be the rule rather than the exception. In our work it has been the exception to find that our heaviest laying hens are the best breeders of laying stock. Why this is so has not been definitely determined, but from our experience this plan can not be recommended.

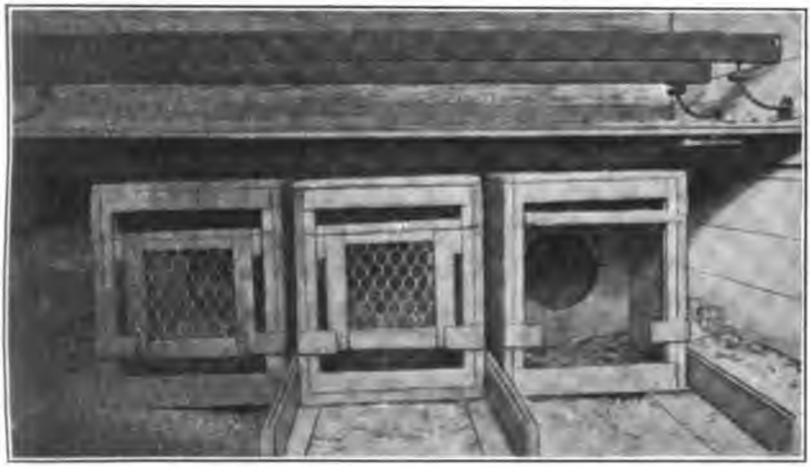


FIG. 3 -Two compartment trap nests used at the Station.

It must not be thought from this that it is considered impossible to improve the laying quality of the flock by breeding, but in order to do so one must know more about the breeders, than simply how many eggs each hen has laid in a year.

Accurate pedigrees must be kept as well as the egg records, so that the breeding ability of the hens may be known as well as their egg production.

It has been found that hens of only medium value from the standard of egg production have sometimes been the best producers of good average laying stock. Under a method of selecting the best layers only for breeders these hens would have been discarded and their value as breeders never discovered.

It is not recommended that hens below the average of the flock in egg production be retained as breeders, but those giving yields up to

Google

or about the average should be retained till their daughters can be tested.

The average egg production of a hen's daughters is a much better guide to her value as a breeder than the records of her ancestors.

In order to keep the pedigrees and get the individual egg records, a trap nest of some kind is necessary. Trap nests are generally made larger than ordinary nests, and in many cases are divided into two compartments. The ordinary sized nest is too small when the hen is confined as long as she sometimes is in the trap nest, and if there is only one compartment the egg is often broken by the hen becoming restless after she has laid. In the two-compartment nest the back part is arranged for the nest proper and the front for the hen to wait in till the attendant releases her from the nest. Fig. 3 shows the trap nest used at the Station.

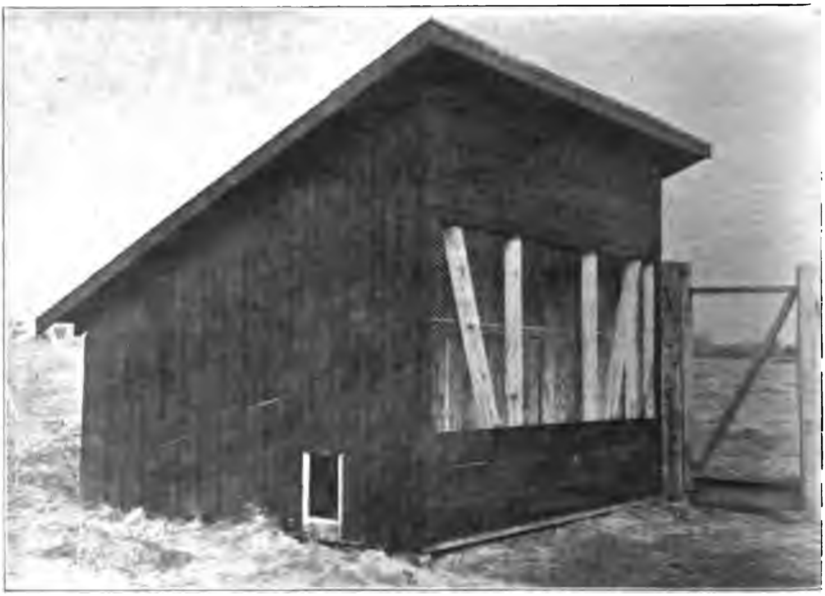


FIG. 4—Wire-front house with shed roof.

The problem of housing the fowls is not as serious in the South as it is in colder climates where the fowls are confined to the house for long periods by cold weather and snow. In this climate fowls spend more of their time in the yards or fields, even in winter, the houses being used only at night and as a protection against wet and the wind.

Even in the North the warm poultry house has been largely abandoned, as in most cases it was found that a closely built house, while warmer, was not as satisfactory as the open-front house with its abundance of fresh, dry air.

Fowls are well protected by their feathers from the cold, but are not comfortable if exposed to wind or wet.

All the fowls used in Station experiments last year were housed in open-front houses, and there was not a single frozen comb in any of these.

A poultry house should be dry, have an abundance of fresh air without drafts, have all the sunlight possible, and should be so built that it can be kept clean and free from mites.

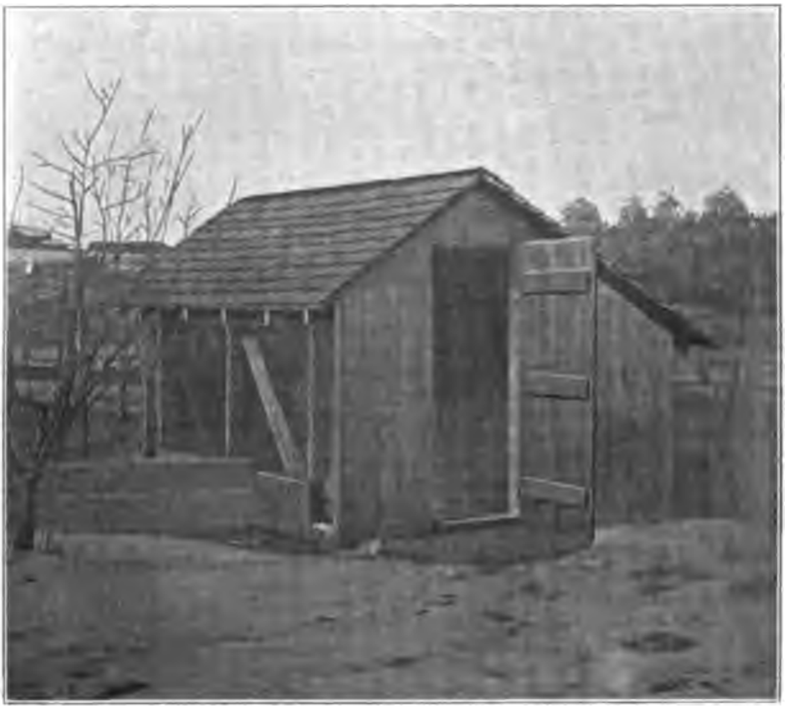


FIG. 5—Wire-front house with long and short pitch roof.

The wire-front house supplies these conditions, and can be cheaply built. Figs. 4 and 5 show some types of wire-front houses and the scratching shed house in Fig. 6 has been converted into a wire-front house by removing the large sash from the windows of the roosting room.

No poultry house will be as dry as it should be unless it is on well-drained ground. If there is not good natural drainage, the ground should be raised to provide artificial drainage.

The house should face the south or southeast, so as to get as much sunlight as possible. Sunlight not only helps to keep the house dry, but is also a good germ destroyer. The opening in the front of the house should be so placed that the sunlight will get to the back of the house. For this reason the house shown in Fig. 4 is preferred to that in Fig. 5, as the opening is higher and the sunlight has a better chance to reach the back of the house.

Lice and mites are two of the worst foes of poultry, and as the latter live in the house, attacking the fowls when on the roost or in the nest, precautions should be taken in building the house to provide as few hiding places for them as possible.

Fig. 3 shows a stop-louse roost hanger which prevents mites traveling from the walls of the house to the roosts. All fixtures, such as roosts, dropping boards, and nests, should be movable, so that they can be taken out when the house is whitewashed or sprayed.

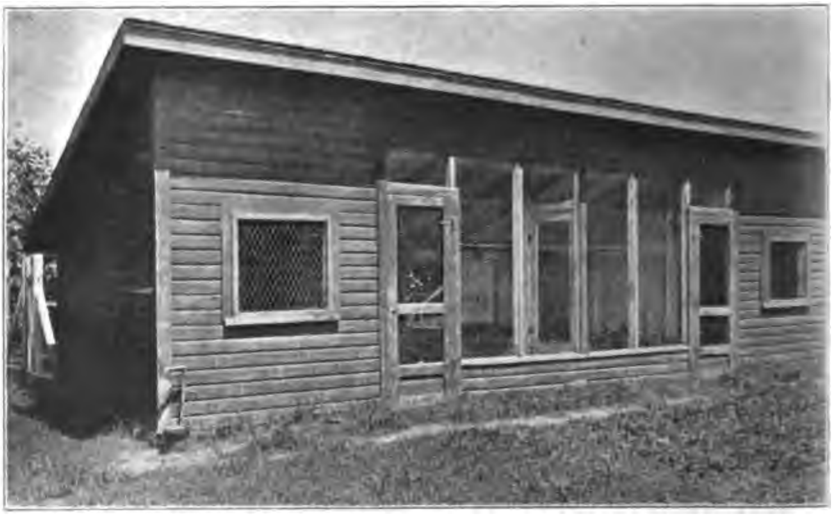


FIG. 6—Scratching shed house used without sash in roosting room.

The scratching shed house shown in Fig. 6 is a very satisfactory house, and the hens have always done well in it, but it is more expensive to build than a single compartment house of the same size, and will not accommodate as many hens, as the roosting room is smaller.

In the wire-front houses (Figs. 4 and 5), we prefer the shed roof, as it is easier to build, the opening can be placed higher in the front, and a roof sloping to the north makes a cooler house in summer. The roofing facing the north will not be exposed to the sun as much as if facing the south, and should last longer. The scratching shed house is set on a concrete foundation; the small open-front houses were raised a few inches above the ground and filled in with light, sandy soil. The ground around the house was also graded so as to give drainage away from the house.

The concrete foundation is best, but on account of the expense is not often used for small houses.

FOOD REQUIREMENTS OF THE HEN

The hen needs food to sustain life; to build up, develop, and repair waste tissues; and to supply heat and energy for the proper functioning of the body. What is fed above these needs goes to the production of meat or eggs.

The composition of the hen's body will vary with her condition, but may be said to contain about 55 per cent water, 22 per cent protein, 17 per cent fat, and 4 per cent ash.

An egg contains about 66 per cent water, 12 per cent protein, 10 per cent fat, and 12 per cent ash. Of the ash, practically all but about one per cent is from the shell.

A glance at these figures shows one the importance of a plentiful supply of pure fresh water. Water is not food, but without water food is of no use to the fowl. Animals as well as plants must have their food in solution before they can use it. When the food is digested it is taken up by the blood, which circulates through the body, nourishing and replenishing it.

Next to water, protein is the food element found in largest amount both in the hen and in the egg. This element builds up the body and repairs the waste tissues. Protein, although the principal nutrient used for a tissue builder, can also be used to take the place of carbohydrates and fat if these are not sufficiently supplied in the ration. It is not economy, however, to have this take place, as the protein is more expensive than the carbohydrates or fat.

Carbohydrates, which are principally starches, sugars, organic acids and pentosans, are used to produce heat and energy. They are the fuel and, while not found to any extent in the body of the hen or the egg, are very necessary in the ration and in fact form the largest part of it.

Fats have to a large extent the same function as carbohydrates. They have about two and one-quarter times the fuel value of carbohydrates, and it is customary in figuring the nutritive ratio of a ration to bring the carbohydrates and fats to a common value by multiplying the latter by two and one-quarter and adding the product to the carbohydrates. Fats also act as a storehouse for surplus supplies on which the fowl can draw when necessary.

Ash or mineral matter is also needed for the bones of the fowls and for the shell of the eggs.

Protein is found more or less in all grains; legumes, such as peas and beans, having more than grain such as corn and wheat. Cottonseed meal, linseed meal, the meat meals, and beef scrap contain more protein than the grains do, and some of these products are often used to supply this nutrient.

Carbohydrates form a large part of most grains and grasses. Corn is perhaps the best example among the grains of a carbonaceous feed. containing as it does 70 per cent carbohydrates and 5 per cent of fat. Fat is also found more or less in most grains, corn and oats containing more than wheat or barley. Meat meal and beef scrap also contain from 5 per cent to 20 per cent fat.

Ash is not found in grains to any large extent, corn having only 1.5 per cent and oats 3 per cent. Wheat bran and middlings have more, the former on an average having nearly 6 per cent and the latter 3.3 per cent.

Some of the animal feeds, such as beef scrap and bone meal, supply larger proportions of ash, and the results of our feeding experiments indicate that a larger percentage of ash is needed than is supplied by grain and grain products and that some of the animal feeds which are commonly used for poultry feeding are deficient in ash and are improved by the addition of bone meal.

Crushed oyster shells are often recommended to supply lime for laying hens, but the results of our experiments indicate that bone meal is a much better source of lime than oyster shells.

WHAT CONSTITUTES A GOOD RATION

A good ration must contain the feed nutrients necessary for the support of the body and the production of the desired product, whether it be meat or eggs. It must also supply these in a form which is palatable or which is relished by the hens, and must be derived from products which are not too high in price.

In addition to the ration which will fill these conditions, it is necessary to have a good supply of green feed for the hens, which serves a double value. In addition to its food value, must be added the benefit it gives in keeping the fowls in good health, thereby enabling them to get the best results from the more concentrated part of the ration. This is especially true where corn supplies the larger part of the ration, as it does in many cases, especially on the farm.

In most places in this State the condition of high-priced feeds and a limited variety has to be met.

Corn can be had everywhere and hens relish it as well as any other grain, but it is not a good exclusive feed for any animal. It is true that on many farms practically nothing else is fed to the poultry and they get along and at some seasons give a fairly good supply of eggs. The eggs generally come at the season of the year when the hens can find a great deal of their feed in the fields. It will be found by examining the tables that follow that the hens that depended largely on corn did not give many eggs and what they did give cost more to produce than they could be sold for.

Wheat is not generally as available as corn and is usually higher in price. It is well liked by fowls and is, perhaps, the best grain for poultry feed if one is confined to one kind. It is specially good for warm weather, as it does not contain as much of the heating materials as corn.

When it can be secured at a price which permits of its being used for poultry feed we like to feed wheat for one-third of the grain ration during winter and increase the proportion as the weather gets warmer till we feed two-thirds wheat and one-third corn.

We have confined our grain ration to corn and wheat because they are the only grains that can be secured regularly. Marketable wheat can not always be used because the price is often too high. When this condition arises, substitution of wheat screenings for wheat is made.

Oats are not often fed, as the price is generally higher than can be afforded. When they can be had at a cent and a half a pound they may be used to advantage. They are not as well liked by the fowls as either corn or wheat, and fowls that have not been accustomed to them do not eat them freely if supplied in a mixture of grains. Crushed or ground and fed in the mash they are eaten quite readily, and it is usually preferred to feed them in this way.

Corn and wheat make up by far the largest part of our feeding stuffs, as not only were the fowls fed these two grains whole, but in most of the rations corn meal and wheat bran formed the base of the mash.

The variation in the ration was made in the products used to supply protein and ash. For this purpose meat meal, cotton seed meal, and bone meal were used.

The meat meal used was guaranteed to contain 85 per cent protein and 7 per cent fat. Analysis showed that it went slightly over these figures.

This was a very concentrated meal, carrying nearly as much protein as dried blood.

According to the common practice of buying animal feeds by their protein content it was cheaper than a 55 per cent beef scrap which cost one-half cent per pound less. The results obtained showed that it was lacking in ash and very much cheaper egg production and better development of the fowls was obtained when bone meal was added to the ration.

The cotton seed meal used was the regular meal sold for fertilizing and feeding purposes and which under the State law must contain 7.5 per cent ammonia or 38.58 per cent protein.

The bone meal contained—

Phosphoric acid	20.22 per cent.
Lime	28. per cent.
Protein	26.47 per cent.

It was used primarily for the phosphoric acid and lime which it contained, but the analysis showed that it also carried considerable protein.

In all feeding experiments, an effort has been made to keep the rations as simple as possible and to use only products that the farmer raises or can obtain on the local market.

Rations which necessitate the buying of half a dozen different products may be good, but there is not much likelihood of the farmer using them on account of the trouble in getting the different ingredients.

METHOD OF FEEDING

For the same reason, a system of feeding that would not require too much labor on the part of the feeder has been aimed at.

It has been demonstrated that fowls do better where they have part of their ration of grains, either whole or cracked, and part of it of ground products or what is commonly called a mash. Until within the last few years, it has been the custom to feed this mash wet. This necessitated the mixing of the mash fresh for each feeding and required a great deal of extra work in mixing and feeding. On this account the farmer has never taken to the feeding of mash. With the introduction of the feeding of this part of the ration dry, from hoppers or feed boxes, the objection to it has been largely done away with and it can now be fed with less labor than can grain. Enough mash can be mixed and put in the feed boxes to last for a week or ten days with no more work than was necessary for the feeding of the day's ration under the old method. Not only is there this great saving in labor, but it has been shown that hens return a greater profit on the dry-mash-hopper feeding system than on the wet mash, without taking into account the labor in either case.

In some of our feeding experiments with cotton seed meal, it was found that the hens did not eat the mash freely, and it was thought that by feeding a wet mash or fermenting the cottonseed meal with yeast, as has been done in some other feeding work with cottonseed meal, this trouble might be avoided, but the work necessary to prepare the mash in this way would have been very much against it in everyday use, and it was not tried.

Fig. 7 shows the box from which the mash is fed. This is a home-made box and serves the purpose very well. It would be improved by putting the slats on the inside of the front and having a wire screen to cover the front at night to keep out rats.

Fig. 8 shows a galvanized iron feed box in which the food is covered by a grating of expanded metal. The hens get their food

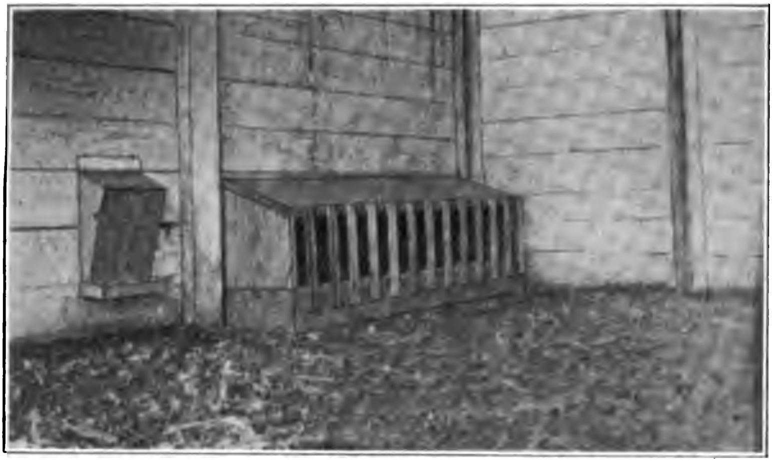


FIG. 7—Home made box for feeding dry mash.

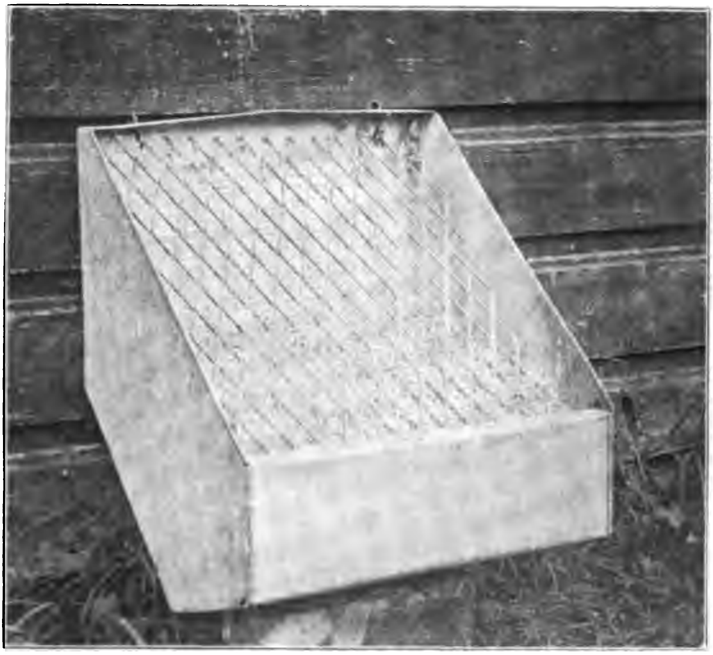


FIG. 8—Galvanized iron feed box for dry mash.

through this grating and are thus prevented from pulling a part of the mash out of the hopper in their search for the ingredients they like best. By hooking the lower end of the grating up at night, the hopper is made rat-proof.

FOWLS USED

With the exception of pen 21, which was made up of Buff Orpingtons, all the fowls used in these experiments were Barred and Buff Plymouth Rocks.

In all cases except pens 24 and 25, one pen each of Barred and Buff Plymouth Rocks were fed on each ration in order to eliminate as far as possible any difference due to the variety. In lots 24 and 25, only one pen was fed on each ration.

Pens Nos. 1, 2, 12, 13, 14, 15, 20, 21, 24, and 25 were pullets when the experiment started. Pens 22 and 23 were yearling hens. Each pen contained ten females and one male at the beginning of the experiment.

RATIONS

The grain fed all pens consisted of a mixture of corn and wheat in the proportions of two to one.

The mash varied in the different pens and was as follows:

Pens 1 and 2	Corn meal	4 parts.
	Wheat bran	4 parts.
	Wheat middlings	4 parts.
	Bone meal	2 parts.
With meat meal in hopper at all times.		
Pens 12 and 13	Corn meal	4 parts.
	Wheat bran	4 parts.
	Meat meal	2 parts.
Pens 14 and 15	Corn meal	4 parts.
	Wheat bran	4 parts.
	Meat meal	2 parts.
	Bone meal	2 parts.
Pens 20 and 22	Corn meal	4 parts.
	Wheat bran	4 parts.
	Cottonseed meal	4 parts.
Pens 21 and 23	Corn meal	4 parts.
	Wheat bran	4 parts.
	Cottonseed meal	4 parts.
	Bone meal	2 parts.
Pen 24	Corn meal	9 parts.
	Cottonseed meal	6 parts.
Pen 25	Corn meal	9 parts.
	Meat meal	3 parts.
	Bone meal	3 parts.

The rations were fed the same to both pens from December 1, 1908, to May 31, 1909.

From June 1, 1909, to August 31, 1909, one pen on each ration was continued on the original ration; the other pen was fed skimmilk in place of the meat meal or cottonseed meal which they had been fed during the first period.

All the fowls were yarded. Pens 12, 13, 14 and 15 had rye in the yards. Pens 1 and 2 had a run on a field of rye every third day.

Pens 20, 21, 22, 23, 24 and 25 were allowed a run on oats and clover half of every third day during the winter. Their yards were set in Bermuda grass and this furnished abundance of green feed after the first of May.

From the nature of our lots it was impossible to get exactly the same conditions for all of the lots in regard to green feed, but none of the fowls suffered at any time from lack of this.

TABLE I.—Showing Cost of Feeding Each Pen, Eggs Laid, Gain or Loss in Weight, Cost of Eggs and Deaths in Each Pen, First Period, December 1, 1908, to May 31, 1909.

Pen No.	Cost of Feeding.	Eggs Laid.	Gain or Loss in Weight.	Cost of Eggs.				Deaths.
				Not Considering Weight.	Average of Two Pens.	Considering Weight.	Average of Two Pens.	
1	$6.64	307	-2¾	25.92		27.00		2
2	7.09	422	1½	20.16	22.56	19.68	22.80	0
12	6.20	191	-4¼	38.76		40.92		1
13	7.80	253	7	37.00	37.56	33.60	37.08	1
14	7.74	481	8	19.20		17.28		0
15	7.36	498	7⅞	17.64	18.48	15.84	16.44	2
20	5.42	225	2⅜	28.92		27.72		1
22	4.55	378	--7⅝	14.40	19.80	16.80	20.88	0
21	5.55	286	—11⅛	23.28		26.40		2
23	6.67	402	—7⅝	19.92	21.24	22.08	26.40	1
24	6.21	148	6⅞	50.28		44.76		1
25	8.46	374	16⅜	27.12		21.94		0

COST OF EGG PRODUCTION

Table I shows the cost of egg production on the different rations for the first period. Each fowl was weighed when the experiment started and at the end of each month till the close of the experiment.

The cost of eggs per dozen is shown after valuing the gain or loss in weight and without taking the weight into consideration. All feeding stuffs were charged at actual cost in the local market. These prices were as follows:

Corn	$30.00 per ton.
Wheat and wheat screenings	30.00 per ton.
Wheat bran	30.00 per ton.
Wheat middlings	32.00 per ton.
Cottonseed meal	30.00 per ton.
Meat meal	60.00 per ton.
Bone meal	30.00 per ton.
Skim milk	5.00 per ton.

The total cost of food per pen of ten hens varied from $4.55 to $8.46 for the six months. Pen No. 22, which was fed for $4.55 for the six months, produced eggs at 14.40 cents per dozen without taking account of gain or loss in weight. When they are charged with a loss of weight of 7 5-8 pounds, the eggs cost 16.80 cents per dozen.

This was a pen of Barred Plymouth Rock hens that were in good condition at the beginning of the experiment, but lost about three-quarters of a pound each during the six months and only averaged 37.8 eggs each during this time.

A ration on which hens would only produce 37.8 eggs each in six months and lose three-quarters of a pound each in weight must be lacking in some of the qualifications of a good ration. In this ration the greatest fault seemed to be that it was not palatable to the hens, and as a result they did not eat much of it, hence the low cost per hen for feeding.

Pen 25, which cost $8.46 to feed for the six months, laid just about the same number of eggs as Pen 22, making an average of 37.4, but the ten pullets gained 16 3-8 pounds or 1.63 pounds each. The eggs cost 27.12 cents per dozen, not allowing for gain in weight, and 21.94 cents per dozen after allowing for the gain made.

The eggs in this case cost more per dozen than in the former. This ration, while palatable, was too high in price, due to the large proportion of meat meal used.

Pens 1 and 2 were fed corn meal, wheat bran, wheat middlings, and bone meal in the mash and meat meal in a separate hopper. For some reason the amount of meat meal eaten varied greatly at different times, and the results were not so good as where a stated amount was fed in the mash.

Pen 1 had two deaths during the first period and two during the second. This was the highest of any pen in the experiments, and amounted to forty per cent. The first two deaths were due to eversion of the oviduct. Whether there is any connection between these deaths and the large amount of meat meal eaten at certain times during the experiment it is impossible to say. The other two deaths were due to digestive disorders.

The average cost of egg production for the two pens was 22.56 cents per dozen, not estimating weight, and 22.80 cents per dozen when the weight was considered. The small loss in Pen 1 due to the two deaths was nearly made up by the gain in Pen 2.

Pens 12 and 13, which were fed meat meal without any bone meal, made very unsatisfactory records. There was one death in each pen during the first period and none in the second. The pullets in Pen 12 weighed practically the same each at the end of the first period as at the beginning, and those in Pen 13 gained just about one pound each.

In neither pen was the egg production satisfactory, the averages being only 19.7 and 26.2 eggs each for the six months. The cost of egg production was high, and each pen showed a loss, Pen 12 of 27.6 cents per hen and Pen 13, of 18.9 cents per hen.

Pens 14 and 15 were fed the same ration as Pens 12 and 13, except that bone meal was added to the mash. In Pen 15 there were two deaths, one just a few days after the experiment started and the other in May. Each lot made an average gain of about .8 pound in the six months and laid an average of 48.1 and 54.8 eggs per hen for each pen.

The average cost of eggs for the two pens was 18.48 cents per dozen, not considering weight, and 16.44 cents per dozen allowing for gain in weight.

Pens 20 and 22 were fed on a ration containing cottonseed meal, and a reference to Table I will show that the cost of feeding the hens in these pens was considerably less than for Pens 14 and 15, being $5.42 and $4.55, against $7.74 and $7.36, respectively. As previously stated, Pen 22 was made up of yearling hens, while the other pens were pullets.

Pens 21 and 23 were also fed a ration containing cottonseed meal, but had bone meal in addition to the ration fed to Pens 20 and 22. It will be noted that we did not get the same results in this case from the addition of the bone meal as we did where it was added to a meat meal ration in Pens 14 and 15. The only explanation of these different results from the use of bone meal that can be offered at this time is the much smaller amount of mash eaten by Pens 21 and 23 as compared with Pens 14 and 15.

Table IV shows the percentage of mash to total food eaten by all pens. This shows that in Pens 14 and 15, 45.1 per cent of their total food was mash, while in Pens 21 and 23 only 31.5 per cent was mash. Pens 24 and 25 were fed rations that did not have any bran and had more cottonseed meal and meat meal than the other rations.

Neither of these rations were satisfactory. Pen 24 only laid 148 eggs during six months, and these cost 50.28 cents per dozen, not allowing for gain in weight, and 44.76 cents per dozen when allowance is made for gain in weight. This is the highest price that eggs cost on any of the rations fed during the first period.

Pen 25 laid 374 eggs during the six months and gained 16 3-8 pounds. Egg production was only fair, but gain in weight was the largest of any lot fed.

TABLE II.—SHOWING COST OF FEEDING EACH PEN, EGGS LAID, GAIN OR LOSS IN WEIGHT, COST OF EGGS, AND DEATHS IN EACH PEN, SECOND PERIOD, JUNE 1, 1909, TO AUGUST 31, 1909.

Pen No.	Cost of Feeding.	Eggs Laid.	Gain or or Loss in Weight.	Cost of Eggs.		Deaths.
				Not Considering Weight.	Considering Weight.	
1	$2.02	112	—11⅝	21.60	33.96	2
2	3.80	323	12⅝	14.04	9.43	0
12	1.78	65	—5⅝	32.76	42.	0
13	3.62	312	13	13.92	9.30	0
14	2.97	282	1⅜	12.60	12.	0
15	3.41	326	—1⅞	12.48	13.20	1
20	3.61	289	9⅜	15.	11.07	0
22	2.36	119	4⅜	23.88	19.32	0
21	1.76	47	—8⅜	45.36	66.	1
23	2.83	159	—1¼	21.24	22.20	1
24	3.16	323	6	11.70	9.50	0
25	2.62	279	—3¼	11.27	12.10	0

Table No. II shows the results for the second period, from June 1 to August 31.

In Pens Nos. 2, 13, 15, 20 and 23, skim milk was substituted for meat meal or cottonseed meal, whichever had been used to supply protein.

It will be noted that in all cases the cost of feeding was greater when skim milk was used than it was where the original ration was continued, but in all cases except Pens 14 and 15 the number of eggs laid was greatly increased and the cost per dozen much reduced.

Pens 14 and 15 made the best record during the first period, and there was very little difference between them in either period. In the second period there was a slight advantage with Pen 14, owing to one death in Pen 15.

Comparing Pens 1 and 2 for this period with the first, we find in Pen 1 a decrease of about 4 cents per dozen for the second period when weight is not considered, and for Pen 2 a decrease of 6 cents per dozen, but when allowance is made for gain in weight, Pen 2 produced eggs at 9.43 cents per dozen on the milk against 19.68 cents on the original ration. Comparing Pens 12 and 13, the results are even more in favor of the milk ration. In Pens 20 and 22, the conditions found during the first period are reversed. Pen 22 during first period produced eggs at 16.80 cents per dozen and during the second period at 19.32 cents. From Pen 20, during the first period, eggs cost 27.72 cents, and during the second 11.07 cents per dozen.

TABLE III.—Showing Cost of Feeding and Eggs Laid per Hen per Month; Gain or Loss in Weight per Hen and Cost of Eggs per Dozen on Rations Containing Meat Meal, Cottonseed Meal and Skim Milk.

Ration.	Cost of Feeding per Hen per Month.	Eggs Laid per Hen per Month.	Gain or Loss in Weight per Hen.	Cost of Eggs.	
				Not Considering Weight	Considering Weight.
Meat meal	14.5	7.7	.2	22 20	21.84
Cottonseed meal	8.73	4.8	—.34	22.80	24.24
Skimmilk	9.5	7.5	.53	15.24	12.36

Pen 23 was the only one which did not give good returns on the skim-milk ration. Eggs from this lot cost 22.20 cents per dozen, as against 22.08 cents for the first period.

Pen 24, which had produced only 148 eggs during the six months of the first period at a cost of 44.76 cents per dozen, produced 323 eggs during the three months of the second and at a cost of 9.5 cents per dozen. This ration during the second period consisted simply of corn, corn meal and skim milk.

Table III gives a summary of the results obtained from all pens fed on rations containing meat meal, cottonseed meal and skim milk.

It will be noted that the average cost of eggs on the meat meal rations is much higher than for Pens 14 and 15, where bone meal was used with the meat meal. It was found that the meat meal used did not give good results where no bone meal was used in the ration.

In figuring the gain or loss per hen, the food costs as given on page 56 are used, and it will be noted that these prices are higher than those prevailing in many places, but are the actual costs in this market.

Eggs were valued at 2 cents each all through the year, as this is about the average price obtained by the Station during the year. There is not the variation in price here that is found in many places, according to season. Strictly fresh eggs bring almost as high a price in summer as in winter. Gain or loss in weight was valued at ten cents per pound.

TABLE IV.—For First Period, December 1, 1908, to May 31, 1909, Showing Amount of Different Kinds of Feed Eaten for the Period, Percentage of Mash to Total Food, Cost of Feeding per Hen for the Period. Highest Average and Lowest Egg Yield for Each Pen, Profit per Hen and Average Weight at Beginning and End of Period.

Pen No.	Weight of Feed.			Per Ct. of Mash to Total Feed.	Cost of Feeding per Hen.	Egg Yield.			Profit per Hen.	Average Wt	
	Grain.	Mash.	Animal Feed.			High't	Average	Low'st		Begin'g of Period.	End of Period
1	244	85	53	36.1	76.6	64	35.45	8	—5.9	4.42	5.18
2	272	103	47	35.5	70.9	54	42.2	29	8.5	4.96	4.34
12	274	126	....	31.5	64.2	34	19.7	1	—27.6	4.05	4.02
13	278	201	....	41.9	80.7	38	26.2	12	—18.9	3.6	4.64
14	263	222	....	45.7	77.4	85	48.1	23	29.3	4.85	4.96
15	255	204	....	44.4	81.9	85	54.8	40	40.	3.77	5.25
20	276	84	....	23.3	59.1	33	24.5	5	—5.5	3.37	4.36
21	233	112	....	32.4	65.3	58	33.6	1	—10.	4.16	4.25
22	213	84	....	28.2	45.5	56	37.8	8	25.6	4.85	4.12
23	275	122	....	30.7	69.5	98	41.8	0	9.7	5.58	[illegible]
24	276	120	....	30.3	63.2	47	15.5	0	—24.	3.4	4.54
25	264	275	....	51.	84.6	57	37.4	15	9.7	3.78	[illegible]

Table V.—For Second Period, June 1, 1909, to August 31, 1909, Showing Amount of Different Kinds of Feed Eaten, Percentage of Mash to Total Food, Cost of Feeding per Hen, Highest Average and Lowest Egg Yields, Profit per Hen and Average Weight at Beginning and End of Period.

Pen No.	Weight of Feed.			Per Ct. of Mash to Total Feed.	Cost of Feeding per Hen.	Egg Yield.			Profit per Hen.	Average Wt	
	Grain.	Mash.	Animal Feed.			High't	Average	Low'st		Begin'g of Period.	[illegible] Period
1	73	41	Meat Meal 9	40.6	31.9	32	17.7	11	4.9	5.18	4.98
2	87½	80½	S'm M 432	47.5	36.	48	32.3	12	31.2	4.56	5.82
12	66	47	....	41.5	20.9	23	7.6	0	—.5	4.02	3.52
13	91½	103	432	52.	40.2	40	34.6	10	32.	4.66	6.22
14	95	89	....	48.3	29.7	36	28.2	4	29.	4.96	5.14
15	66½	87	432	56.6	42.2	53	46.1	28	53.8	5.26	5.75
20	90½	83	432	47.8	45.1	46	36.1	24	30.1	4.36	5.65
21	66½	40½	....	37.8	22.9	22	6.1	0	—10.18	4.28	3.69
22	80	49	....	38.	23.6	21	11.9	0	1.2	4.12	4.56
23	83½	81	432	49.2	40.4	48	24.8	0	10.1	5.39	6.52
24	64½	73	432	53.1	35.1	52	38.6	15	45.4	4.54	5.21
25	55	100	....	64.5	26.2	44	27.9	16	31.9	5.42	5.10

Tables IV and V give the amount of food of each kind eaten by each pen for the two periods, the percentage of mash to total food eaten, cost per hen of feeding during each period, the highest, lowest and average egg yield, profit per hen and average weight of fowls at beginning and end of each period.

This latter point will not agree with gain or loss of weight given in Tables I and II, as in this case the average of the fowls actually in pens at the end of period is given, while in the former the total weight of fowls is taken.

For example, take Pen 1. Table I shows a loss in this pen for the first period of 2 3-4 pounds, while Table IV shows a gain in the average weight of .762 pounds each for the six months. The loss in weight in the first case being caused by the two deaths which occurred. A comparison of the value of the different rations can be made by all these tables, but perhaps the best is that shown by Tables IV and V between Pens 15 and 20.

These were two pens of Barred Plymouth Rock pullets of the same breeding and as nearly alike in age and development as it was possible to get them. The ten pullets in Pen 15 weighed 34 1-4 pounds, and those in Pen 20, 33 3-4 pounds.

During the first period, Pen 15 ate 255 pounds grain and 204 pounds mash, at an average cost of 81.9 cents per pullet. Pen 20 ate 276 pounds of grain and 84 pounds of mash at an average cost of 59.1 cents per pullet. Pen 15 laid an average of 54.8 eggs each for the period, gained 1.495 pounds each and made a profit of 40 cents each. Pen 20 laid 24.5 eggs each, gained .985 pounds, and lost 5.5 cents each.

For the second period the rations were the same, except that Pen 15 had bone meal and 20 had none. Pen 15 ate 66½ pounds grain, 87 pounds mash and 432 pounds milk, at a cost of 42.25 cents for each pullet.

Pen 20 ate 90½ pounds grain, 83 pounds mash and 432 pounds milk at a cost of 45.1 cents each. Pen 15 averaged 46.1 eggs each, gained .485 pounds each and made a profit of 53.79 cents each for the three months.

Pen 20 averaged 36.1 eggs, gained 1.29 pounds and made a profit of 30.1 cents each.

It will be noted that these pullets weighed practically the same at the beginning of the first and end of the second period, but at the end of the first period those in Pen 15 weighed .90 pounds each more than those in Pen 20. These latter were not in as good condition at the beginning of the second period as those in Pen 15, and more of their food went to building them up. They gained .805 pounds each more than the others, but laid 10 eggs each less.

The results obtained from Pens 24 and 25 for the two periods should also be noted.

For the first period (six months) Pen 24 laid 148 eggs that cost 44.76 cents per dozen, and made a loss of 24 cents each for the period.

For the second period (three months) this pen laid 323 eggs, which cost 9.5 cents per dozen, and made a profit of 45.4 cents each. The only change in the ration being the substituting of skim milk for cottonseed meal.

Pen 25, in which the original ration was continued through both periods, laid during the first period 374 eggs which cost 21.94 cents per dozen and made a profit of 9.7 cents each in six months. In the second period they laid 279 eggs, which cost 12.60 cents per dozen and made a profit of 31.9 cents each.

Pens 20 and 22 had the same ration for the first period, but for the second cottonseed meal was replaced by skim milk in the ration for Pen 20. Pen 22 was continued on the original ration.

For the first period Pen 20 laid 225 eggs and Pen 22, 378. In Pen 20 eggs cost 27.72 cents per dozen and in Pen 22 they cost 16.80 cents per dozen.

In Pen 20 the hens lost 5.5 cents each, while in Pen 22 they gained 25.6 cents each during the same time.

For the second period, Pen 20 laid 361 eggs at a cost of 11.07 cents per dozen, while Pen 22 laid 119 at a cost of 19.32 cents per dozen. Hens in Pen 20 gained 30.1 cents each and those in Pen 22 gained 1.2 cents each.

CLEANLINESS

It is quite possible to have the best stock, kept in well-built houses, well fed, and still not get any profit or pleasure from them. In too many cases where a good start has been made the house is neglected and allowed to become filthy and infested with mites. It may be said that filth and mites generally go together, for while a house that is kept fairly clean may be infested with mites, it is very seldom that a dirty house will be found to be free from these pests.

Lice and mites cause more losses among poultry than all other things combined. This is especially true of Southern poultry, as a hot climate is especially favorable to the rapid increase of these parasites.

In the remarks about houses some suggestions were made as to how the house should be arranged inside to enable the poultryman to keep down the mites without an undue expenditure of time and energy. Mites live in the house and must be killed there. Dusting the hens will never get rid of them.

The best means of getting rid of mites in the houses is to spray thoroughly with kerosene emulsion. This should be done twice with an interval of from five to seven days between the sprayings.

The emulsion is made as follows: Cut up one pound of soap and dissolve it in hot water; while the water is hot, stir in two gallons of kerosene and continue stirring for fifteen to twenty minutes. It is important to have the kerosene, soap and water well mixed, especially if it is not to be used at once. To this mixture add seventeen gallons of water. This makes a ten per cent emulsion. Some recommend fifteen per cent, but we have found ten per cent efficient in killing the mites.

Kerosene used on the roosts once a week in hot weather will help to keep down both mites and lice. If put on a short time before the hens go to roost, some of it will get on the feathers and will kill and drive away lice. Care must be taken not to get too much on the fowls, or it will blister them and this will stop the hens from laying just as much as the lice will. Good, vigorous hens kept in a clean house and given a good place to dust and wallow in should not need any special attention to keep them free from lice. The dusting with insect powder of a large number of hens is a tedious and disagreeable job, and with proper conditions should not be needed. Hens that are not vigorous and those that are sick will often be found to be lousy, and many think that the lice make them sick. Lice are the result rather than the cause of sickness. When the hen becomes sick she is not able to defend herself and becomes an easy prey to lice. In a case of this kind, and when hens are set, they need dusting with a good insect powder, but there is something wrong with the stock and the management if frequent dustings are necessary.

When it is necessary to use an insect powder, care should be taken to get one that will kill the lice without injuring the hens. Some of the insect powders put up especially for poultry use are so strong that they will injure the hens. A few years ago, at the Experiment Station, a setting hen was killed by the liberal use of a powder that contained considerable naptholin flakes, and just this spring hens were killed near here by the use of insect powder of the same make, and some that did not die were so injured that they stopped laying for two to three weeks. The parties dusted their hens to kill the lice in the hopes of getting a better egg yield, but the results were that the egg yield instead of increasing fell off about fifty per cent for ten days after the use of the powder.

Pyrethrum or Persian insect powders may cost more, but they are better and are not so dangerous to use as are the powders which depend largely on naptholin to kill the lice.

CONCLUSIONS

The following conclusions may be drawn from the feeding experiments conducted during the past season:

Cottonseed meal is not relished by hens as well as the animal sources of protein are. On that account is not as well adapted to poultry feeding, as the fowls ate very sparingly of the mash containing it.

Pullets were slower in developing and in coming to laying maturity on a ration containing cottonseed meal than on one containing meat meal.

Hens did better than pullets on rations containing cottonseed meal, as shown by Pens 20 and 21 in comparison with Pens 22 and 23, the latter two being hens. As far as can be judged from the work done, the main objection to cottonseed meal is its lack of palatability.

High protein meat meal, although readily eaten by the fowls, did not give satisfactory results either in egg production or development of the fowls.

Lime furnished by oyster shells did not supply the deficiency of ash in some of the rations, as all pens had oyster shells available at all times.

The best results in egg production during the first period were obtained from the two pens fed a mash containing meat meal and bone meal.

During the second period the best results were obtained from the pens fed skim milk.

Rations which gave the lowest cost per hen for feeding did not give the greatest profit per hen during either feeding period.

During the first period, Pen 22, which was fed at a cost of 45.5 cents per hen for six months, came third in profit per hen. Pens 14 and 15, which cost 77.4 cents and 81.9 cents per hen, respectively, gave a greater profit per hen for the period.

During the second period the three pens that were lowest in feed cost were Nos. 12, 21 and 22. The first two were fed at a loss and the last at a profit of only 1.2 cents per pen.

Pen 15, which cost more than twice as much per hen to feed, gave a profit of 53.79 cents per hen for the three months.

Hens fed skim milk during the second period not only laid more eggs at less cost per dozen, but gained more in weight and came to moulting time in better condition than those on any other ration.

Bone meal did not seem to be as necessary when skim milk was fed, as Pens 13 and 24 gave good returns during the second period. The mash for the former was corn meal and wheat bran and for the latter corn meal only.

The pens fed skim milk during the second period cost more per hen for feed, but gave better returns for feed consumed than those on other rations.

BULLETIN 212 OCTOBER 1910

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

PREVENTION OF OAT AND WHEAT SMUT

Edwards & Broughton Printing Co.,
State Printers

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh
E. M. KOONCE	Jacksonville
T. W. BLOUNT	Roper
D. A. TOMPKINS	Charlotte
J. T. ELLINGTON	Smithfield
W. E. DANIEL	Weldon
W. H. RAGAN	High Point
W. B. COOPER	Wilmington
M. B. STICKLEY	Concord
T. T. BALLINGER	Tryon
N. B. BROUGHTON	Raleigh
O. L. CLARK	Clarkton
EVERETT THOMPSON	Elizabeth City
R. H. RICKS	Rocky Mount
O. MAX GARDNER	Shelby
M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
G. A. ROBERTS	Veterinarian
R. I. SMITH	Entomologist
J. C. MCNUTT	Dairy Husbandman
J. D. CECIL	Animal Pathologist
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
F. W. SHERWOOD	Assistant Chemist
L. R. DETJEN	Assistant Horticulturist
GUY WEST WILSON	Assistant in Vegetable Pathology
T. B. STANSEL	Assistant Bacteriologist
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS

PAGE.
Smuts; their nature and cause 75
Kinds of smut 75
Period of suceptibility to infection 77
OAT SMUT: Amount of damage 78
Amount of oat smut in North Carolina 78
Preventive measures prior to the introduction of formalin 78
    Bluestone treatment 78
    Hot water treatment 79
The introduction of formalin as a smut preventive 79
Experiments concerning injury to seeds 81
Work in North Carolina 81
Press bulletin and free distribution to teachers, Farmers' Institutes 82
WHEAT SMUT.
    Treatment for stinking smut 82
    Treatment for loose smut 82

PREVENTION OF OAT AND WHEAT SMUT.

By F. L. Stevens.

Nature and Cause—Smut, Bunt, Black Heads, these are a few of the names under which one of the most common and widespread diseases of cereals is known in this State.

The disease shows itself to the farmer as a black, dusty, or hard mass, usually occupying the place where the grain should be. The mass of dust is really composed of the fruiting bodies, the reproductive parts of the fungus, which are the real cause of the diseased condition. This fungus is a vegetable parasite. It gains entrance to the plants when they are in a susceptible condition of development, this varying with different kinds of plants, grows within the plant as an active parasite, drawing its nourishment during this time from its involuntary host. When the host plant has attained the proper age, and correspondingly, too, the fungus has reached its proper stage of maturity, the disease becomes apparent to the eye as the only too familiar *smut*. Each individual grain of the dusty mass of smut if enlarged sufficiently by magnifying glasses reveals itself as a minute ball of varying size, shape, and marking, according to the particular kind under view.

Smut spores under suitable conditions of moisture, food and heat will sprout and produce smaller spores (*sporidia*) which, if they fall upon the proper host plant in the proper period of its development, will penetrate into it and grow. The host plant may or may not outgrow its enemy. In any event its presence is not apparent to the naked eye until the period of maturity arrives again and another crop of black spores is produced.

Kinds of Smuts—In all there are many kinds of smuts. Something more than two hundred and sixty-eight species are now recorded. About two hundred and five of these are found in the United States growing upon some four hundred and forty-two different kinds of plants[1].

Most smuts are upon unimportant, uncultivated plants. Some of them, such as the *corn* smut, *onion* smut, and the smuts of *wheat, oats, rye, barley,* attack plants of high economic value and cause great damage. The common *corn smut* develops upon almost any part of the corn plant, but is usually most conspicuous upon the ear and tassel. *Onion* smut is in the leaves, often in the bulb. *Rye smut* in the stem; that of *oats, wheat* and *barley* in the ovary, the grain. Another smut of *corn* growing upon the tassel is less widely known.

On *wheat* three kinds of smut are to be recognized; one which shakes out freely from the head, leaving the empty chaff behind. other two which remain in the chaff as a black, somewhat oily where the grain should be. The first mode of behavior has given

---

[1] G. P. Clinton, Proc. Boston Soc. Nat. Hist., Vol. 31, No. 9, p. 334, 1904.

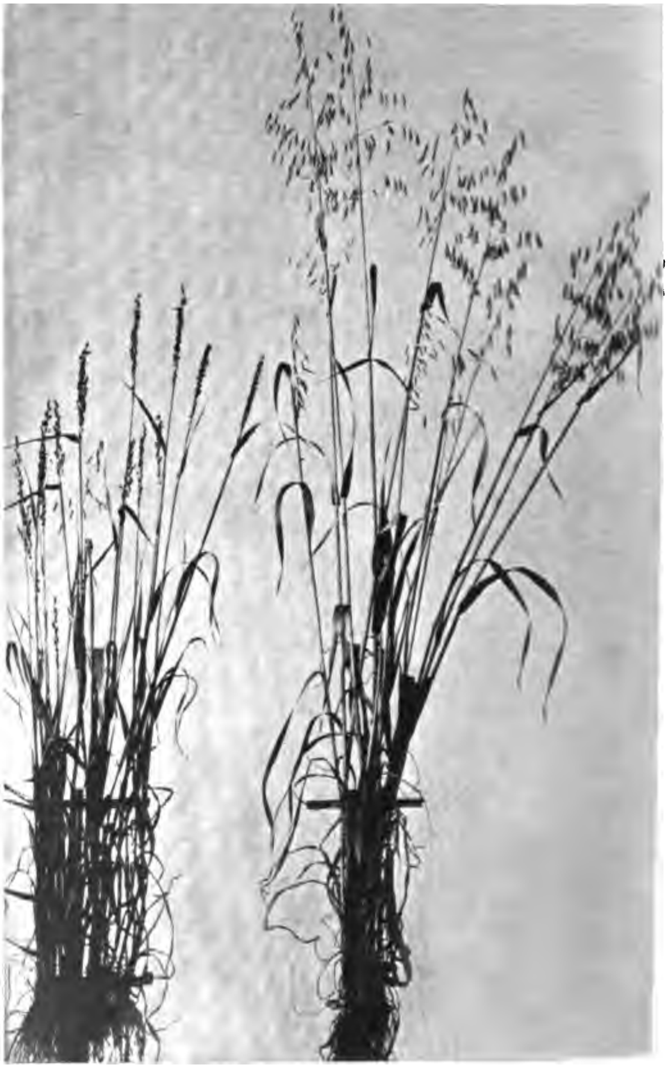


Fig. 1—Oat Plants, smutted and healthy. Note the short stems of the smutted plant

to the term *loose smut*. The disagreeable odor pertaining to the other kinds of wheat smut gives to them the popular name of *ing smut*. They are also often called *bunt*.

On *oats* there are two kinds of loose smut, but they are so closely alike that only the expert can distinguish between them, and he only by the use of a very powerful microscope.

On *rye* one smut is known, infecting chiefly the leaf sheaths. On cultivated *barley* are two species of loose smut.

PERIOD OF SUSCEPTIBILITY TO INFECTION.

If sporidia fall upon proper parts of the host plant, and at proper age of development of the host plant, infection will follow. If no sporidia are present, or if they fall upon places that are of improper age to be susceptible, or that for other reasons are not susceptible, no infection can occur.

It is evident that to know precisely at what parts and at what periods the various crop plants are open to infection is of utmost importance in looking to the prevention of the disease.

It was early proved that *oats* are susceptible to infection only in very young periods of their development. Kuhn[1] and Wolff[2] held opposing views as to whether it was the young stem or the first leaf sheath that was susceptible. The very exact work of Brefeld[3] settled this point beyond all controversy. Brefeld also proved that corn is susceptible to infections on all young tender growing parts and recently Maddox in Tasmania, Wakagwa in Japan, Brefeld[4] in Germany, have shown that in the case of the *loose smut of wheat* and the *barley smut* infection occurs while the plant is in bloom, this infection affecting the seeds and resulting in smutted plants in the crop raised from such infected seeds.

It is upon these facts that our present modes of prevention are based. The treatment for oat smut is such as to kill the spores adhering to the grain and thus prevent infection during the period of susceptibility, *i. e.,* the very young seedling condition. The same treatment is effective for the stinking smut of wheat. The loose smut of wheat gaining entrance to the embryo in the seed plant before the grain is harvested can not be prevented by such means but can be prevented by the use of the means given below.

Corn being susceptible at all ages of its growth can not be protected by seed treatment, and the only recourse is to cut out and destroy (burn or bury) all the smut possible each year and thereby diminish the number of smut spores floating in the air. The heat of the silo is sufficient to kill corn smut spores, and the silo will undoubtedly be an important factor in lessening the amount of smut in the country.

---

[1] J. Kuhn, Die Krankheiten der Kulturgewachse. Berlin, 1859.

[2] Wolff, der Brand des Getreides, Halle, Germany, 1874.

[3] Oscar Brefeld, Untersuchungen aus dem Gesammtgebiete der Mykologie. Heft 11, 1895.

[4] Oscar Brefeld and R. Flack, Untersuchungen aus dem Gesammtgebiete der Mykologie Heft 13, 1905; die Bluteninfktion bei den Brandpilzen und die naturliche Verbreitung der Brandkrankheiten.

AMOUNT OF DAMAGE.

The damage caused by smut is usually underrated. In 1884 Arthur[1] in New York by actual count found the oat smut to constitute from 8.5 to 10 per cent of the ordinary crop. In 1886, Plumb[2] by actual count of nearly 11,000 heads determined the amount of smut to be 8.4 per cent; in some fields he found as high as 20, 25, and even 30 per cent. Kellerman and Swingle[3], counting smutted heads in Kansas, found different fields to have 8, 15.3, 18.3 per cent of smut, while single portions of a field had as high as 39 per cent.

AMOUNT OF DAMAGE FROM OAT SMUT IN NORTH CAROLINA.

This disease occurs in all parts of North Carolina where oats are grown. In eighteen counties in the summer of 1908 examination was made for smut, some 65,000 heads of oats being counted. In no field was oat smut absent, and the amount by actual count in several instances was as high as 18, 19 and even 24 per cent.

In one county, with the aid of the local threshers, a conservative estimate was made of the amount of oats raised and of the amount of smut prevailing. From the county clerk the amount of taxes collected was ascertained. It was apparent that the loss from oat smut (a natural tax levied upon those ignorant of the method of preventing smut) slightly more than equalled 10 per cent of the taxes levied by man. How hard does man strive to lower the tax levy! How much does he object to its increase! Yet many a man without resistance allows this equally burdensome and totally unproductive smut tax to be collected yearly without putting forth the trifling effort that is needed to nullify it.

PREVENTIVE MEASURES.

Owing to their great damage and conspicuousness smuts have attracted attention from very early times and many references to them are found in ancient writings. Probably not until 1791, however, was their true nature as vegetable parasites recognized. Many, however, were the means that were suggested for the prevention of these pests; placing laurel branches in the field, change of seed, avoidance of manures, thorough screening, soaking in brine, etc.

Bluestone Treatment—The only one of the early treatments that has proved its value and remained in common use is that of soaking the seed wheat in copper sulphate (bluestone). Tessier, in 1789, after he, in 1786, and Young in 1787, had tested numerous chemicals, seems to have been the first to try this treatment for smut. His test was without results since neither treated nor untreated wheat was smutted that year. It remained for Prevost, of France, in 1807, to first publish an account of the successful use of the bluestone for wheat smut. He recommended a solution of about six per cent strength, and the remedy was, and is still, widely used. Various strengths have been employed, one-half per cent being the most highly recommended.

---

[1] J. C. Arthur, Third Report N. Y. State Station, 1884, p. 382.
[2] C. S. Plumb, Fifth Report N. Y. State Station, 1886, pp, 125 *et seq*.
[3] W. A. Kellerman and W. T. Swingle, Second Report Kan. Exp. Station, 1890, 223.

In 1873, Dreisch improved the bluestone treatment by using lime water to follow the bluestone, thus, to a large extent, diminishing the amount of seed killed by the treatment.

The best form of the bluestone treatment (for wheat) is to soak the seed in one-half per cent solution for twelve hours, then for five minutes in milk of lime. This is very effective against the stinking smut of wheat, but does not entirely prevent oat smut[1].

HOT WATER TREATMENT.

Jensen, a Dane, in 1887 and 1888, reported excellent results with oat, barley and wheat smuts from dipping the seed in hot water.

Untreated seed gave 36 per cent of smut.
One-fourth per cent bluestone gave one-half per cent smut.
Warm water, 133° F., 5 min., gave no smut.

The rationale of this treatment is that the smut spores succumb at a temperature of 132° F. for 5 minutes while the grain seed is uninjured by this temperature for 15 minutes.

This method of smut prevention, somewhat modified, has like the bluestone treatment, been very widely employed. It is effective. The only objections to it are its difficulty of manipulation and the great care that is needed to maintain the proper temperature so as surely to kill the smut spores, but as surely to avoid injuring the grain.

FORMALIN TREATMENT.

While the foregoing treatments are good, a still better one is the formalin treatment first introduced in 1897.

Formalin is the commercial name for a 40 per cent solution of formaldehyde in water. Formaldehyde was discovered in 1888. It is made by passing a mixture of air and wood alcohol vapor over heated platinum.

The germicidal value of formalin was first discovered by Trillat in 1888, since which time it has come into prominence as a fungicide. In 1895, Geuther[2] published a paper in which he showed formalin capable of destroying the germinating power of smut spores without injuring the grain.

Formalin was first used and thoroughly tested in America as a preventive for oat smut by Prof. H. L. Bolley, of North Dakota Agricultural Experiment Station, during the three years preceding

---

[1] W. A. Kellerman and W. T. Swingle, Second Report Kan. Exp. Station, 1890, p. 241.

[2] Th. Geuther Einwirkung von Formaldehyde-losungen auf Getreidebrand. Ber d. deut. Pharm. Gesell., 5, 1895, 328.

1897. In March, 1897, Professor Bolley published his results in bulletin form[1]; Prof. C. P. Close, of New York Station, published a bulletin in December, 1897, presenting the results of some experiments with formalin treatment during that year[2]. During the winter of 1897-98, Prof. M. B. Thomas, of Indiana, read a paper[3], describing experiments concerning the effect of formalin upon the germination of seed oats and suggesting that it might be well to try this substance upon the spores of smut as a possible smut prevention. In 1898, Neger[4] and Tubeuf[5] also published bulletins concerning the relation of formalin to smuts of cereals.

Since the publication of these papers, many Agricultural Experiment Stations have concurred in their recommendations and the use of the formalin treatment has extended to probably every country where oats are grown.

In the various experiments many strengths of formalin have been tested. The strongest solution recommended for use is one pound of formalin to twenty-five gallons of water; the weakest, one pound to one hundred gallons, while by far the greater number of experimenters recommended one pound of formalin to fifty gallons of water.

TREATMENT FOR OAT SMUT AND WHEAT STINKING SMUT.

Two methods of treatment are recommended.

1. A solution is made of one pound of formalin to fifty gallons of water and placed in a barrel or large tub. The seed is then placed in bags and immersed for ten to twenty minutes, or until thoroughly wet, then taken out and dried and stored, or planted immediately. If stored, great care must be exercised not to place the seed where smutted seed has been before or where there is any possibility of smut spores being carried to it. If drilled at once the drill will have to be set to sow more than the usual quantity of seed to the acre to allow for the extra size of the swollen seed.

2. The other method, more easily employed and more to be recommended, consists in sprinkling the seed instead of immersing it. The same strength of solution, that is, one pound to fifty gallons of water, is used.

To treat the grain spread it in thin layer on a smooth barn floor and sprinkle with the diluted formalin, using either a spraying machine or a watering pot. Sprinkle so as thoroughly and evenly to wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution and cover the pile with canvas, carpet, blankets or bagging, to keep the fumes of the formalin within. The pile should stand from 6 to 12 hours in this way. The oats may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning mill. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection. The best way is to treat, dry, then sow as soon as practicable.

---

[1] H. L. Bolley, New Studies upon the Smut of Wheat, Oats and Barley, with a resume of treatment experiments for the last three years. (N. Dak. Sta. Bul. 27, 1897, pp. 109-164.)

[2] C. P. Close, Results with Oat Smut in 1897. N. Y. Station Bul. 131, pp. 441-454.

[3] M. B. Thomas, The Effect ef Formalin on Germinating Seeds. (Proc. Ind. Acad. Science, 1897. 144-148).

[4] F. W. Neger, Ueber Desinfekton von Saatgut mittels Formaldehyde-Dampfe. Praktische Blatter fur Pflanzenbau und Pflanzenschutz, Vol. 1, No. 11. November, 1898, pp. 84-85.

[5] Carl von Tubeuf, Scherings Formalingas-Methode. Praktische Blatter fur Pflanzenbau und Pflanzenschutz, Vol. 1, No. 11, November, 1898, pp. 85-86.

In general, one gallon of mixture will suffice to treat one bushel of grain. The formalin should be used at the rate of one ounce to three gallons of water.

Formalin is an irritating caustic which should not be brought into contact with the skin in pure form. In diluted condition it is harmless.

Formalin can be purchased from the druggist at a cost of 75 to 95 cents a pound, thus making the cost of treatment not more than 2 cents to the bushel of grain. The gain in increase of yield is estimated at from $1.00 to $5.00 per acre.

EXPERIMENTS CONCERNING INJURY TO SEEDS.[1]

Owing to the many strengths of formalin recommended for the prevention of smut, experiments were undertaken in 1905 to determine what strength is dangerous to the germinating power of the seed. Formalin of the following strengths was used: one ounce to one gallon; one ounce to two gallons; one ounce to three gallons, and one ounce to one-half gallon. The trials showed that the strongest solution quite materially injured the germinating power of the grain, while the other three strengths did not injure the seeds appreciably.

Further experiments were carried out to test the various strengths upon several varieties of oats. It was found that three of the six varieties tested showed much more resistance to the formalin than the other three varieties used.

Tests of the effects of different times of application of the solution were made and it was found that one ounce to one gallon may be used with comparative safety for a period of two hours, and that one ounce to two gallons is dangerous when used for 12 hours.

It was further found that good, heavy, plump seed gave better germination tests after treatment than either average, medium, or poor (light) seed.

WORK IN NORTH CAROLINA.

While the oat crop is not of leading importance in this State, its aggregate is large, amounting to 2,500,000 bushels in 1900. The loss through oat smut is therefore a significant item in State economy.

---

[1] F. L. Stevens, Thirty-First Report N. C. Station, 1909, p. 30.

Since this disease is so easily prevented and at such trifling cost, every effort has been made to call the attention of the farmers of North Carolina to the loss and methods of preventing it. In 1902, the work was begun by writing to prominent farmers and explaining the treatment to them, sending gratis a sample of formalin sufficient to treat an acre of oats, and a circular giving directions for its use. The distribution of this formalin was further effected by offers made at many farmers' institutes and through various agricultural papers, and through press bulletins published in local papers during the past eight years. Letters were also sent to several hundred school teachers of the State, attempting through them to call attention to the formalin treatment and offering to send free samples to any patron of their schools who would agree to try it and report results.

Many of the farmers who tried the formalin failed to report the results, a few accepted it but for some reason failed to test it. The great majority who received samples tested the treatment and returned to this Experiment Station statements attesting its efficiency and their letters are now here on file. A very few failed to note any beneficial effects owing to the fact that there was little or no smut on the untreated field used for comparison with the treated field.

The efficiency of the formalin treatment has thus been thoroughly demonstrated to the farmers of North Carolina, and many farmers have adopted its use as a permanent practice and the object lessons afforded by these farmers are rapidly leading to a general use of this valuable mode of disease prevention.

WHEAT SMUTS.

As is said on page 76, there are two kinds of smut common on wheat, the *loose smut* and the *stinking smut.*

The *stinking smut* may be prevented by the use of one-half per cent bluestone or formalin. Either treatment is good. The formalin is best. It is employed just as for the prevention of oat smut.

The *loose smut* finds its way into the plant in the very young condition of seed, *i. e.,* before the seed ripens, indeed while the wheat plant is yet in blossom. In the ripe seed the fungus is within the seed itself and is beyond the killing influence of chemical steeps. The bluestone or formalin method employed against the stinking smut of wheat and against oat smut are therefore of no avail. The discovery that infection occurs in the seeds at the time of blooming, however, leads to the suggestion that if one avoids using seed that was exposed to infection during blooming there will be little or no danger from loose smut and conversely if one employs seed that came from a field containing much loose smut such seed is probably infected and will result in a smutted crop.

One remedy against loose smut of wheat is, therefore, when practicable, to use only seed from fields that were free of loose smut. In many instances such seed can not be obtained. It then becomes necessary to treat infected seed so as to procure from it a sufficient quantity of uninfected seed. This can be accomplished by a modified form of the Jensen hot-water treatment. The directions for procedure drawn from Freeman and Johnson[1] are as follows:

A good, clean, well-cultivated piece of land should be selected for raising seed. The plat should be large enough to provide at least twice as much grain as will be necessary for farm seed the following year in order to allow for loss in cleaning and selecting. This seed plat should not lie near fields of smutted crops of the same cereals, nor should it be so located that the prevailing winds at flowering time can carry spores to the seed plat from a neighboring field of the same grain. This isolation is absolutely necessary. A strip of wood, a corn field, or a large meadow is a valuable protection.

After seed for the plat has been cleaned by the best fanning and sifting, it must be treated by the Jensen method. The clean seed should be soaked for from five to seven hours in water at ordinary room temperature, 17° to 22° C. (63° to 72° F.), then placed in small, loose sacks or wire baskets, containing not more than one-half peck each, and drained for a short time. The seed must be treated in

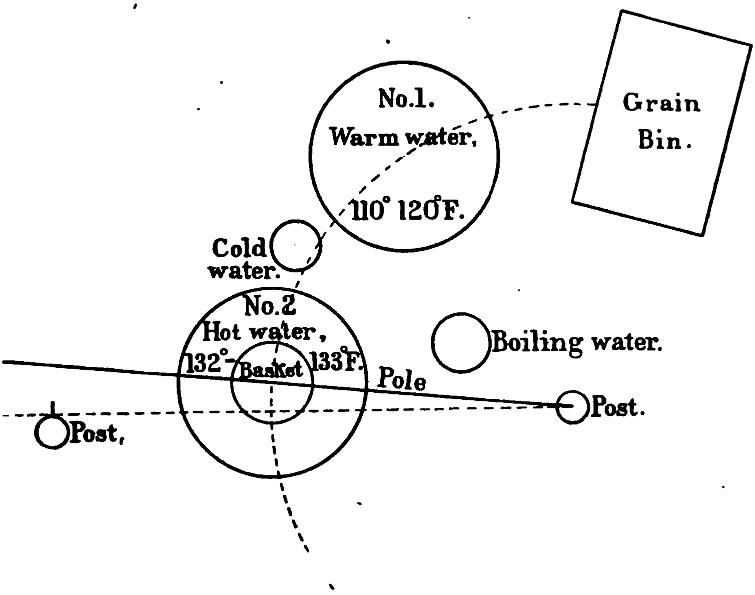


FIG. 2.—Diagram showing arrangement for treating smutted seed.

---

[1] E. M. Freeman and E. C. Johnson, U. S. Dept. Agr. Bur. Plant Indus., 152, July 12, 1909.

small lots in order that all of the grain may quickly and uniformly reach the desired temperature. Two tubs or vats of water should be provided. In one tub (No. 2) the exact temperature required should be maintained. The other tub (No. 1) is used for bringing the grain to the temperature in tub No. 2. Galvanized iron tubs of 20 to 40 gallons' capacity, and kerosene or gasoline double-burner stoves are convenient.

The drained sacks or baskets of seed should be plunged into tub No. 1 for a minute, then transferred to tub No. 2, and kept agitated while immersed at temperatures and for the periods specified below, the temperatures mentioned being maintained as nearly as possible: For barley, 15 minutes at 52° C. (125.6° F.). For wheat, 10 minutes at 54° C. (129.2° F.). In treating barley, if the temperature should rise above 52° C. (125.6° F.), the time of immersion must be reduced to ten minutes at 53° C. (127.4° F.), or five minutes at 54° C. (129.2° F.). Above 54° C. (129.2° F.) there is no safe margin. If the temperature falls slightly below 52° C. (125.6° F.), the time of treatment should be increased in proportion. A temperature lower than 51° C. (123.8° F.) is not effective. In treating wheat, if the temperature should rise above 54° C. (129.2° F.) or fall below 52° C. (125.6° F.), the time for immersion must be diminished or increased accordingly. Under no circumstances should a temperature of more than 55° C. (131° F.) be allowed. Temperatures below 51° C. (123.8° F.) are ineffective. A reliable thermometer is necessary, since the use of an inaccurate instrument may result in injury to the germinating power of the grain or in failure to prevent the smut.

The men working together can easily treat one bushel of grain an hour, or enough seed in one day to sow a seed plat of from 6 to 10 acres. The seed may be dried by spreading it out in thin layers not over 2 ins. in depth on a clean granary floor or on canvas, and shoveling or raking it from time to time. It should not be allowed to sprout. Care must be taken to prevent freezing of the grain when it is moist, as this will impair germination.

Seed treated as indicated may be planted as soon as it is sufficiently dry to run freely through the drills, making allowance for the swollen seed. Before sowing the seed should be tested for germinating power, and a corresponding increase in the rate of seeding be made.

The seed plat may be maintained from year to year, or as long as any smut is present in the grain fields. Seed obtained from the treated seed plat does not have to be treated the following year.

BULLETIN 213 OCTOBER 1910

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
OF THE
COLLEGE OF AGRICULTURE AND MECHANIC ARTS
WEST RALEIGH

FEEDING EXPERIMENTS WITH COWS AND CALVES

Edwards & Broughton Printing Company,
State Printers.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLINGER	Tryon
T. W. BLOUNT	Roper	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. T. ELLINGTON	Smithfield	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
R. I. SMITH	Entomologist
G. A. ROBERTS	Veterinarian
J. D. CECIL	Animal Pathologist
J. C. MCNUTT	Dairy Husbandman
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
L. R. DETJEN	Assistant Horticulturist
F. W. SHERWOOD	Assistant Chemist
T. B. STANSEL	Assistant Bacteriologist
GUY WEST WILSON	Assistant in Plant Diseases
A. F. BOWEN	Bursar
C. P. FRANKLIN	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS

PAGE.

Narrow versus Medium Rations for Cows 89
- Plan of experiment 89
- Results 89
- Table showing Milk, Butterfat Test and Butterfat Yield and Live Weight 90
- Table showing total yield of Milk and Butterfat and total Live Weight 91
- Second Trial 91
- Table showing Milk, Butterfat Test and Butterfat Yield and Live weight 92
- Table showing Total Yields of Milk, Butterfat and Live Weight 93
- Comparison of results of the two trials 93

Relative Economy of Narrow and Medium Ration 93

Health of Cows 94

Relative Feeding Value of Cottonseed Meal and Linseed Meal for Milk Production 94
- Results 95
- Table showing Milk, Butterfat Test, Butterfat Yield and Live Weight 95
- Table showing Yield of Milk and Butterfat and Total Live Weight 96

Linseed Meal as a Tonic Food 96

Miscellaneous Feeding Trials with Cows and Calves 96

FEEDING EXPERIMENTS WITH COWS AND CALVES

By John Michels

NARROW VERSUS MEDIUM RATIONS FOR COWS.

In most sections outside of the cotton belt the cost of protein feeds is high in comparison with those of a carbonaceous nature. In the South with its abundance of cottonseed meal, protein is relatively cheap. Because of these facts, the work of the stations outside of the cotton belt has been directed mainly toward securing data as to how wide a ration can be successfully fed to dairy cows. Obviously, from what has been stated above, an important problem with the North Carolina farmer is to determine how narrow a ration can be successfully fed. The experiment reported in this bulletin, therefore, was undertaken with a view of determining the relative economy of a narrow ration and of a medium wide ration.[1]

PLAN OF EXPERIMENT.

The experiment was divided into three periods of twenty-eight days each. In periods I and III a narrow ration was fed consisting of 5 parts cottonseed meal, 4 parts wheat bran, 3 parts corn meal and 50 pounds corn silage. This ration had a nutritive ratio of approximately 1:4. During period II the ration was the same as in periods I and III, except that 2.5 pounds of cottonseed meal were replaced by 2.5 pounds of corn meal, giving this ration a nutritive ratio of approximately 1:5.7. Each period was preceded by ten days preliminary feeding.

Eight cows from three to six weeks in lactation were used for the experiment. Cows Nos. 6 and 7 received 9 pounds of grain; Nos. 1 and 4, 10 pounds; No. 2, 11 pounds; and Nos. 3, 5 and 8, 12 pounds. The grain was always fed before the roughage.

The milk from each cow was weighed daily, and composite samples of it were tested weekly by the Babcock test. The cows themselves were weighed once a week throughout the experiment.

RESULTS.

The results obtained from the individual cows during the different periods are presented in the following table:

---

[1] In a wide ration there is less protein in proportion to carbonaceous matter than in a narrow ration.

TABLE I—SHOWING MILK, BUTTERFAT TEST AND BUTTERFAT YIELD AND LIVE WEIGHT.

No. Cow.	Period.	Milk.	Butter-fat—Per Cent.	Butter-fat—Pounds.	Average Weight of Cow—Pounds.
	I. Narrow ration	560.8	5.1	28.6	756
1	II. Medium ration	522.0	4.5	23.4	762
	III. Narrow ration	491.0	4.8	23.5	771
	I. Narrow ration	622.9	5.6	34.8	837
2	II. Medium ration	645.8	5.5	35.5	837
	III. Narrow ration	561.4	5.7	39.1	835
	I. Narrow ration	857.8	4.4	37.7	702
3	II. Medium ration	753.9	4.3	32.4	691
	III. Narrow ration	752.6	4.5	33.8	674
	I. Narrow ration	555.5	5.4	29.9	758
4	II. Medium ration	467.1	4.6	21.3	761
	III. Narrow ration	433.1	5.4	23.3	782
	I. Narrow ration	761.9	4.0	30.4	932
5	II. Medium ration	696.2	4.0	27.8	900
	III. Narrow ration	675.7	4.1	27.7	897
	I. Narrow ration	455.7	5.8	26.4	856
6	II. Medium ration	407.0	5.9	24.0	852
	III. Narrow ration	354.0	5.9	20.8	865
	I. Narrow ration	432.1	4.6	19.8	748
7	II. Medium ration	405.1	4.5	18.2	744
	III. Narrow ration	380.8	4.9	18.6	746
	I. Narrow ration	701.6	4.3	30.1	1,004
8	II. Medium ration	570.2	4.1	23.4	1,013
	III. Narrow ration	630.7	4.1	25.8	1,021

The results presented in Table I show that with one exception all cows produced more butterfat during the first period than during the second, while in the third period some cows produced a little more, and some a little less butterfat than was produced in the second period. The weight of the cows was practically the same throughout the experiment except of cows Nos. 3 and 8. Cow No. 3

gradually lost in weight, while cow No. 8 gained during the progress of the trial. Attention is also called to the test of the milk, which was perceptibly lower with most cows during the middle period than either during the preceding or following period.

The results of the experiment are brought out more forcibly in the following table:

TABLE II.—SHOWING TOTAL YIELD OF MILK AND BUTTERFAT AND TOTAL LIVE WEIGHT.

Period.	Milk—Pounds.	Butter-fat—Per Cent.	Butter-fat—Pounds.	Total Live Weight—Pounds.
I. Narrow ration	4,978.3	4.90	237.7	6,623
II. Medium ration	4,668.3	4.67	206.0	6,580
III. Narrow ration	4,279.3	4.92	205.6	6,593
Average of Periods I and III	4,628.8	4.91	221.5	6,610

Comparing the average results secured in periods I and III with those of period II it is found that the narrow ration produced 7.5 per cent more butterfat, increased the butterfat test 0.24 per cent and the total live weight 30 pounds. The milk yield was practically the same.

SECOND TRIAL.

The results of this trial are rather contrary to matters generally regarded as fairly fixed, namely, that the feed does not influence the richness of milk and that a fairly wide ration is more efficient than a narrow one. In view of this it was thought desirable to duplicate the work to see if the results obtained could be substantiated or reasonably duplicated.

In the second trial the kind, amount, and proportion of feed as well as the general method of recording results, were the same as in the first trial. To add strength to the results, however, it was thought best to reverse the feeding periods. In the first trial the narrow ration was fed during the first and third periods and the medium ration during the second period. In the second trial the medium ration was fed during the first and third periods and the narrow during the second. The number of cows in the first trial was eight, while only five were used in the second trial. The results obtained from the individual cows during the different periods of the second trial are presented in the following table:

TABLE III. Showing Milk, Butterfat Test, Butterfat Yield and Live Weight.

No. Cow.	Period.	Milk—Pounds.	Butter-fat—Per Cent.	Butter-fat—Pounds.	Average Weight of Cows—Pounds.
1	I. Medium ration	519.1	5.60	29.20	852
	II. Narrow ration	500.8	6.00	30.05	865
	III. Medium ration	468.8	6.15	27.83	876
2	I. Medium ration	632.1	5.55	35.08	903
	II. Narrow ration	591.3	6.06	35.83	890
	III. Medium ration	499.0	6.23	31.10	899
3	I. Medium ration	752.8	3.7	27.85	934
	II. Narrow ration	754.7	3.86	29.13	961
	III. Medium ration	617.1	4.15	25.61	993
4	I. Medium ration	733.6	4.75	34.85	769
	II. Narrow ration	648.0	5.62	36.42	765
	III. Medium ration	551.0	5.73	31.59	760
5	I. Medium ration	636.7	4.48	28.49	794
	II. Narrow ration	581.7	4.88	28.39	809
	III. Medium ration	536.1	4.77	25.45	820

The table shows that with one exception all cows produced more butterfat during period II when the narrow ration was fed, than in either the preceding or following periods during which the medium ration was fed. The exception is cow No. 5, which yielded slightly less butterfat in period II than in period I, but considerably more than in period III.

The rise in the per cent of butterfat is very marked in changing from the medium to the narrow ration, but far less so in changing from the narrow to the medium ration, indicating that the narrow ration tends to raise the per cent of butterfat in milk.

The yield of milk gradually dropped from the beginning to the close of the test except in the case of cow No. 3, which gave slightly more milk in Period II than Period I. Three cows gained in weight during the trial, while two lost slightly in weight, the loss or gain being uniform from the beginning to the close of the test.

The results of the experiment are brought out more forcibly in the following table:

TABLE IV.—Showing Total Yields of Milk, Butterfat, and Live Weight.

Period.	Milk—Pounds.	Butterfat—Per Cent.	Butterfat—Pounds.	Total Live Weight—Pounds.
I. Medium ration	3,274.3	4.82	155.47	4,252
II. Narrow ration	3,076.5	5.28	159.82	4,290
III. Medium ration	2,672.0	5.40	141.58	4,351
Average of periods I and III	2,973.1	5.11	148.52	4,301

Comparing the average results secured in periods I and III with those of period II it will be found that the narrow ration produced 7.6 per cent more butterfat, increased the butterfat 0.17 per cent and the amounts of milk 93.4 pounds, the live weight remaining practically the same.

COMPARISON OF RESULTS OF THE TWO TRIALS.

In regard to the yield of butterfat the results of the two trials are almost identical. In the first trial there was an increase of 7.5 per cent in butterfat yield in favor of the narrow ration; during the second period the increase was 7.6 per cent. The narrow ration also showed a higher per cent of butterfat in both trials, being 0.24 per cent higher in the first trial and 0.17 per cent in the second. The yield of milk was 0.8 per cent greater with the medium ration during the first trial, but during the second trial the narrow ration produced the more milk, being 3.4 per cent greater than that from the medium ration. The live weight of the cows was practically the same for both narrow and medium ration during both trials.

RELATIVE ECONOMY OF NARROW AND MEDIUM RATION.

So far as concerns the experimental results in this bulletin, a comparison of the "narrow" and "medium" rations is equivalent to a comparison of corn meal and cottonseed meal. It was learned that cottonseed meal (narrow ration) produced more butterfat than the corn meal (medium ration), when fed in the quantity and combination as reported in these trials. To get the full difference in the value of these two feeds, however, it is necessary to consider, in addition to their respective values as butterfat producers, also their market and fertilizing values.

It was stated at the outset that the ration fed during Period II was the same as that fed during Periods I and III, except that 2.5 pounds of cottonseed meal were replaced by an equal weight of corn meal. The cost of the former feed was 1.3 cents per pound, while that of the latter was 1.5 cents, making a saving of 0.2 cent per pound in favor of the cottonseed meal.

Comparing the two feeds solely on the basis of their fertilizing value it is found that cottonseed meal is worth 1.4 cents per pound and corn meal 0.38 cent per pound, a difference of 1.02 cents per pound in favor of the cottonseed meal. Adding to this the difference in the original cost of the two feeds, we find that each pound of cottonseed meal replaced by an equal weight of corn meal, effected a saving of 1.22 cents when both the original cost and the fertilizing ingredients are considered. But to this must also be added the increase in the butterfat production, which was found to be 7.5 per cent when 2.5 pounds of cottonseed meal were substituted for an equal weight of corn meal. Valuing butterfat at 30 cents per pound, the extra yield of butterfat increased the returns from cottonseed meal 0.9 cent for each pound fed in place of corn meal. Adding this to the 1.22 cents found above, we find that for each pound of corn meal replaced by an equal weight of cottonseed meal, a saving of 2.12 cents was effected for each pound so replaced. With a herd of ten cows fed one year under the conditions of the experiments detailed here, this would mean a total saving of $193.55.

HEALTH OF COWS.

So far as this experiment is concerned there was nothing whatever to indicate that a narrow ration (1:4) has any detrimental influence on the health of cows. In this connection it may be stated that no positive conclusions regarding this matter could be drawn from a short feeding experiment. The writer's data in reference to this point, however, are not limited to those obtained in the experiments detailed here; they cover four years work with from fifteen to fifty cows, which were fed on an average not less than six months a year on rations containing a nutritive ratio of about 1:4.[1] In all cases where such a narrow ration was fed, corn silage formed the main part of the roughage and we feel positive that no injury can be done a cow by feeding a narrow ration when corn silage forms the main part of the roughage, even when the narrow ration is obtained by feeding concentrates in which cottonseed meal forms the main part, provided, of course, that the meal is in first-class condition.

RELATIVE FEEDING VALUE OF COTTONSEED MEAL AND LINSEED MEAL FOR MILK PRODUCTION.

The experiment was divided into three periods of twenty-four days each, the first seven days of each period being counted as preliminary. In Periods I and III a ration was fed consisting of 10 parts wheat bran, 10 parts cottonseed meal, 5 parts corn meal, and 5 parts linseed meal. The grain ration during the second period differed from this in that 10 parts of linseed meal were fed and only 5 parts of cottonseed meal. Of these grain mixtures, cows Nos. 1, 4 and 5 received 13 pounds daily, while Nos. 2 and 3 received 11 pounds daily. Each cow received uniformly 45 pounds of silage throughout the test. All of the cows were in the early stages of lactation.

---

[1] S. C. Sta. Buls., 117 and 131.

The milk from each cow was weighed daily and composite samples of it were tested weekly by the Babcock test. The cows were regularly weighed once a week.

RESULTS.

The results obtained from the individual cows during the different periods are presented in the following table:

TABLE V.—Showing Milk, Butterfat Test, Butterfat Yield and Live Weight.

No. of Cow.	Period.	Milk—Pounds.	Butter-fat—Per Cent.	Butter-fat—Pounds.	Total Live Weight—Pounds.
1	I. Cottonseed meal	649.9	4.4	28.59	984
	II. Linseed meal	582.6	4.2	24.47	924
	III. Cottonseed meal	538.6	4.2	22.62	912
2	I. Cottonseed meal	370.5	4.1	15.19	992
	II. Linseed meal	342.3	4.1	14.03	995
	III. Cottonseed meal	326.4	4.2	13.70	970
3	I. Cottonseed meal	396.8	5.0	19.84	748
	II. Linseed meal	368.2	4.9	18.04	712
	III. Cottonseed meal	315.2	4.8	15.13	715
4	I. Cottonseed meal	470.2	4.4	20.68	865
	II. Linseed meal	470.4	4.5	21.16	849
	III. Cottonseed meal	476.9	4.5	21.46	855
5	I. Cottonseed meal	577.6	4.1	23.68	766
	II. Linseed meal	530.6	4.2	22.28	735
	III. Cottonseed meal	540.2	4.3	23.22	739

The table shows the yield of milk and butterfat gradually decreased throughout the test except with cows Nos. 4 and 5, which show a slight increase during Period III. The per cent of butterfat was practically the same throughout the test. There was also a decrease in live weight as the test progressed, except in case of cows Nos. 3, 4 and 5, which showed a slight increase during Period III.

The results of the experiment are brought out more forcibly in the following table:

TABLE VI.—TOTAL YIELD OF MILK AND BUTTERFAT AND TOTAL LIVE WEIGHT.

Period.	Milk—Pounds.	Butter-fat—Per Cent.	Butter—fat—Pounds.	Total Live Weight—Pounds
I. Cottonseed meal	2,465.0	4.40	105.46	4,355
II. Linseed meal	2,294.1	4.38	100.48	4,215
III. Cottonseed meal	2,197.3	4.40	96.68	4,191
Average I and III	2,331.1	4.40	102.72	4,273

The table shows that the cottonseed meal gave slightly greater returns than the linseed meal. The difference, however, is so slight that it would seem unwise not to feed a small quantity of the linseed meal in place of cottonseed meal where there is the slightest need of the tonic effect which linseed meal is capable of producing. The cost of a ton of linseed meal averages about 15 to 20 per cent higher than cottonseed meal.

LINSEED MEAL AS A TONIC FOOD.

The great tonic value of linseed meal is evidenced by the fact that most of the so-called patent stock foods and condition powders are largely made up of linseed meal. It is a laxative feed and for this reason large quantities of it should never be fed as a daily ration. It is especially suited to young stock, being rich in growing material, such as protein and ash. Indeed there is no class of farm animals to which some linseed meal cannot be fed to advantage, especially when the animals are deprived for long periods of green or succulent feeds. Linseed meal takes the place of the high price patent tonic stock feeds and costs on an average only about one-tenth as much. Every well regulated stock farm should always be provided with linseed meal.

MISCELLANEOUS FEEDING TRIALS.

Observations have been made as to the effect of feeding cows a ration containing one-third cottonseed meal during the month preceding calving. No ill effects of such feeding were noticeable. It should be borne in mind, however, that the cows received a liberal amount of corn silage during the time these observations were made. Our feeding trials have well established the fact that cottonseed meal can be fed with much greater safety in conjunction with silage than with dry roughage.

In another investigation involving over twenty animals observations were made on the effects of feeding a grain ration, consisting of one-third cottonseed meal, to heifers ranging from six to eighteen months of age. The daily grain allowance ranged from one and one-half pounds for the six months' old heifers to two and three-quarter pounds for the eighteen months' old heifers. The amount of meal fed in these trials did not appear to interfere in the least with the vigor and development of the animals. One-half of the roughage fed consisted of corn silage.

Investigations have also been made on the effects of feeding calves on old pasteurized milk and on skim-milk soured with pure cultures of lactic acid bacteria. In the main, the old pasteurized skim-milk did not appear to have any appreciable effect on calves, though the same had a tendency to produce scours when badly curdled. Feeding skim-milk sourced with lactic acid bacteria did not induce scours; on the contrary, such milk had an appreciable constipating effect. This constipating effect was so marked as to prove quite efficacious in checking calf scours. More data is needed to positively prove to what extent skim-milk soured with pure cultures of lactic can be used as a cure for calf scours.

BULLETIN 214 MARCH, 1911

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

TWO IMPORTANT CANTALOUPE PESTS

EDWARDS & BROUGHTON PRINTING CO.
STATE PRINTERS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W KITCHIN, *ex-officio* Chairman, Raleigh

C. W GOLD	Raleigh
E. M. KOONCE	Jacksonville
T. W. BLOUNT	Roper
D. A. TOMPKINS	Charlotte
J. T. ELLINGTON	Smithfield
W. E. DANIEL	Weldon
W. H RAGAN	High Point
W. B. COOPER	Wilmington
M. B. STICKLEY	Concord
T. T. BALLINGER	Tryon
N. B. BROUGHTON	Raleigh
O. L. CLARK	Clarkton
EVERETT THOMPSON	Elizabeth City
R. H. RICKS	Rocky Mount
O. MAX GARDNER	Shelby
M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
G. A. ROBERTS	Veterinarian
R. I. SMITH	Entomologist
J. C. MCNUTT	Dairy Husbandman
J. D. CECIL	Animal Pathologist
W C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
F. W. SHERWOOD	Assistant Chemist
L. R. DETJEN	Assistant Horticulturist
GUY WEST WILSON	Assistant in Vegetable Pathology
T. B. STANSEL	Assistant Bacteriologist
A. F. BOWEN	Bursar
LOULA V. SHERWOOD	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

Introductory 105
  Melon worm damage in North Carolina 105
  Object of investigation 106
Pickle worm 106-126
  Common name explained 106
  Food plants and feeding habits 107
  History and distribution 108
  Descriptions of—
    Eggs 109
    Worms (larvæ) 109-111
    Cocoons and pupæ 111
    Parent moths 112
  Egg-laying and hatching 113
  Growth and habits of pickle worms 114-115
    Record of rate of development 116
  Pupæ, formation of 117
  Length of life cycle, one generation 118
  Winter condition 119
  Generations each season 120
  Natural enemies 121
  Preventive and remedial measures 122-126
    Squash as trap plant 123
    Destroying infested plants 125
    Deep plowing, rotation 126
    Poison applications 126
Melon worm 126-143
  Common name explained 126
  Food plants and feeding habits 126
  History and distribution 128
  Descriptions of—
    Eggs 129
    Worms (larvæ) 129-131
    Pupæ 133
    Parent moths 133
  Egg-laying and hatching 134
  Larval development and habits 135
  Record of growth of worms and pupæ 137
  Pupæ, formation of 138
  Length of life cycle, one generation 138
  Winter stage 139
  Generations each season 139-140
  Natural enemies 141
  Preventive and remedial measures 141-143
    Trap plants, value of 143
    Poison sprays, value of 143
Bibliography of pickle worm 144
Bibliography of melon worm 145

TWO IMPORTANT CANTALOUPE PESTS

The two insects dealt with in the following pages,—which will be spoken of as the pickle worm, *Diaphania nitidalis,* and the melon worm, *Diaphania hyalinata,*—represent in some respects the greatest obstacle to successful growing of cantaloupes, squash and cucumbers, and certain other cucurbitaceous crops mentioned elsewhere in this bulletin. Growers of these crops are obliged to prevent, or at least attempt to prevent, the work of such insects as cutworms, striped cucumber beetles, melon lice, squash lady beetles, and others, but as a source of injury to the maturing fruit, the two worms discussed in this bulletin are the chief offenders. The pickle worm, is, of the two, the most destructive. In the vicinity of Raleigh, where investigations have been made for the past two seasons, and over the greater portion of North Carolina, it is more injurious than the melon worm. The latter becomes more numerous and destructive in the coastal section and in States farther south. In Georgia and Florida, these two species are often of about equal importance. It would seem that the melon worm has about reached its northern range, as a destructive insect, in the latitude of Raleigh, but the pickle worm is fully as injurious here as it is in Florida.

For two seasons the writer has made a special investigation into the habits, development, life history and extent of injury caused by the melon worms and by the pickle worms. Most of the actual work and observations have been made in the vicinity of West Raleigh. The accompanying illustrations and descriptions should enable the general reader to distinguish between the two species, and the more intimate acquaintance with the work and habits of these worms, will, it is expected, enable growers to prevent some of the annual injury. It is seldom that any direct measures are adopted to prevent the work of these worms, or to prevent their increase. This condition should not exist. Growers of cucurbits should learn how to prevent or check the increase of these worms, even though it is impossible to exterminate them, or to prevent a certain amount of injury each year.

EXTENT OF DAMAGE IN NORTH CAROLINA.

By boring into ripening cantaloupes, cucumbers and summer squash, pickle worms injure these crops to an extent ranging from a small per cent up to nearly total destruction, depending greatly on the season and whether the crops are maturing early or late.

An early-maturing crop of cantaloupes or cucumbers, that is, one harvested before July 1, is not often seriously injured by pickle worms, no matter how numerous they become later in the season. On the other hand, a late July or early August crop may be nearly ruined even around Raleigh, while in the coastal section these insects become numerous somewhat earlier in the season. In the cantaloupe section of Robeson and Scotland counties, some injury occurs when the crop is gathered later than July 10, as was true in 1910. If the season had permitted earlier planting and earlier maturity, the worm injury would not have amounted to two per cent of the crop. In 1910, it often went as high as fifteen to thirty per cent. Around Raleigh, where most of the cantaloupes in 1910 were not gathered until August 1 or later, the worms in some instances destroyed seventy-five per cent, and in a few fields, nearly the entire crop.

The above statements refer particularly to the injury caused by the pickle worms. The other species, known as the melon worms, have not been numerous enough during 1909 and 1910 to prove a serious pest, for when present, they occurred mainly on the foliage of summer squash or boring in the late squash. The writer has seen only a few of this species that were actually boring into cantaloupes and cucumbers around Raleigh, and in squash they were present only late in the season when the crop was of little value.

The actual loss caused by these worms is, therefore, largely dependent on the season, but the writer's observations have shown that the grower can practice methods of rotation, use of squash as a trap plant, and the destruction of remnants of an infested crop, and thereby reduce the injury considerably, and prevent the annual increase of these pests.

OBJECT OF INVESTIGATION.

The study of these two curcurbit worms was undertaken for the purpose of attempting to learn some method of preventing more effectively, than it has been done in the past, the usual amount of injury. It was hoped that the melon worms, *D. hyalinata,* would be made the principal object of study because previous literature has not dealt largely with that species. Fortunately, however, this form has not been destructive in the vicinity of Raleigh during the past two seasons, nor is it liable to become so if parasites continue to reduce its numbers, as they have done in the past. The present bulletin will therefore be confined largely to a statement of what has been learned concerning the habits and development of both species, and mention of predaceous and parasitic enemies. Methods of preventing the work of these worms are fully explained.

PICKLE WORM.

Diaphania nitidalis, Cramer.

REASON FOR COMMON NAME.

A study of the early mention of this insect shows that the name "pickle worm" was first bestowed on it by Riley in 1869 because the worms were then frequently found in pickled cucumbers, as they were being cut for the table. For many reasons this title is not appropriate, for there is scarcely a farmer who knows it by this name, and its usual method of damaging cantaloupes and summer squash would far better call for the name "melon borer." However, since the name pickle worm has been used in literature for so many years, it seems best to retain it. There is still another good reason for retaining this common name, and that is, in order to distinguish it from the other species described in this bulletin as melon worm, *D. hyalinata.* The latter species could much more appropriately be called the striped melon worm, but it seems inadvisable to try to change these names after they have been used for so many years.

FOOD PLANTS AND FEEDING HABITS.

Pickle worms probably feed on nearly all curcurbits, but in North Carolina they work mainly on cantaloupes or muskmelons, summer squash, cucumbers and gourds. Quaintance has observed it on the watermelon, but the writer has never seen a single larvæ on that crop, even though watermelon fields, immediately adjoining cantaloupes in which the worms were very numerous, have been frequently examined. It, therefore, seems quite certain that this worm seldom attacks the watermelon. The pickle worm does not appear to have been recorded in America as feeding on any plants not belonging to the cucurbitaceous family. It certainly does not often cause noticeable injury to any crops except the few mentioned above.

On cantaloupe, squash and cucumber, pickle worms feed freely in the opening bud clusters, in the blooms—particularly large squash blooms,—in fruit of all sizes, and also in the main stem and leaf stems. While the buds, blossoms and fruit are abundant, the worms, if they are not overly numerous, will seldom go into the leaf stems or stalk. Late in the season when the plants are through fruiting, a large number are often found in the main stalk and leaf stems, where their work resembles that of the common squash vine borer, *Melittia satyriniformis.* The favorite feeding place for pickle worms is undoubtedly in the large blooms of summer squash (Fig. 16), or in the unopened buds. Late planted squash and cucumber often have the vines thoroughly riddled and practically killed by pickle worms. The leaf and blossom buds are devoured before they can open, and as these usually furnish insufficient food, the worms burrow in the stems, in which they eat long cavities.

When working on cantaloupe vines, pickle worms are frequently found in the buds and blooms, in which they sometimes become nearly full grown. The real injurious feeding, however, is in the maturing fruit of squash, cantaloupe and cucumbers, which may be considered as the most important crops. Small pickle worms usually make shallow cavities in the rind, but sometimes bore directly through the rind and feed on the interior. The larger worms usually bore directly through the rind, and one worm may make several entrance holes. (Fig. 1.) In the green fruit the worms are content to feed on the interior, but in a ripening cantaloupe they seem to dislike the soft flesh and consequently make several entrance holes or excavate large cavities in the rind. Every one who has grown cantaloupes knows that the fruit soon sours or rots after a worm has made a hole sufficiently deep to allow the air to enter.

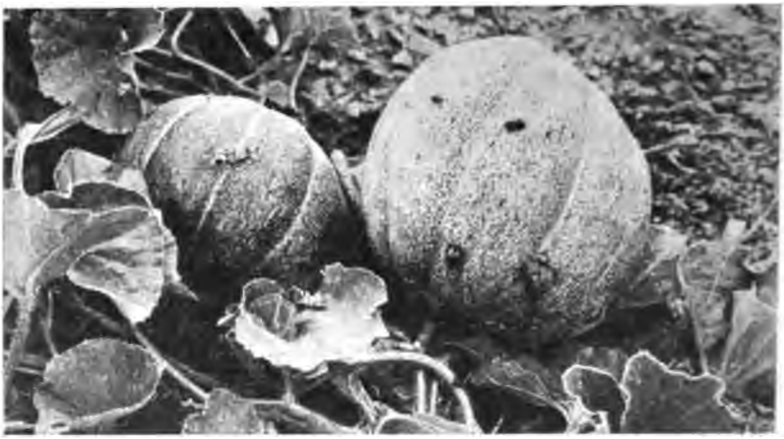


FIG. 1.—Pickle Worm injury to ripening cantaloupes. Photographed in natural position in field. (Original.)

According to practically all published records, pickle worm injury seems to be confined to cantaloupe, muskmelon, cucumber, squash, cashaw and cymlins. Pumpkins seem to be exempt from injury, according to Quaintance, who records pumpkins in Georgia as not infested even when growing adjacent to muskmelons that were eventually destroyed.

HISTORY AND DISTRIBUTION.

The pickle worm moth has been known since 1782, when it was listed by Cramer. In 1794, Fabricius gave its habitat as Austria. It seems, however, that this is an American species. The injurious character of the larvæ seems to have been first recorded by Walsh and Riley in the American Entomologist, in 1869, when it was found injuring cucumbers at Alton, Illinois, Peeverly, Missouri, and St. Joseph, Michigan. During that year the fact that the larvæ were frequently found in pickled cucumbers, was what led Riley to suggest the name pickle worm.

This insect has been reported as occurring in Canada, the United States, West Indies, and in parts of South America. In the United States it occurs in nearly all the South Atlantic and Gulf States, and as for north as New York, and westward through Kansas. It is probably present also through Central America and Mexico. The first illustrated account of the pickle worm is doubtless that given by Riley in his Second Report on Noxious Insects of Illinois, pp. 64-70. At that time considerable injury seems to have been caused by the larvæ to both cucumbers and muskmelons over a large territory. In his article, Riley states that "The worms commenced to appear in the latitude of St. Louis about the middle of July, and they continued their destructive work till the end of December." In another sentence he said that he could find no previous mention of its destructive work, and that it evidently was never destructive enough in the past to attract attention.

In the Report of the United States Commissioner of Agriculture for 1870, Glover figured and mentioned this species briefly. Snow in 1876 reported it as not common in Kansas, and Packard in 1877, French in 1878 and Comstock in 1879, gave this insect brief mention. Since 1883, numerous writers (see bibliography) have made mention of the occurrence and destructiveness of this pest in various parts of the country.

Throughout the North the pickle worm is not often numerous enough to be injurious, but in the South, particularly in the Carolinas, Georgia and Florida, it causes considerable injury every season. Very few cucurbit fields are ever entirely free from this pest in North Carolina and States southward, during the months of summer and fall.

DESCRIPTIONS.

Eggs. (Fig. 2.)

Freshly deposited eggs are of a pearly white color, but change to yellowish after about twenty-four hours, and to a deeper yellow before hatching, when the shape of the larva is easily detected through the nearly transparent shell. The surface of the shell is faintly marked with raised, irregular lines forming four, five and six-sided areas. The shape of the eggs varies greatly, dependent on the surface on which they are deposited, and on the number of eggs laid in the masses, which vary from two to six or seven. Eggs are seldom placed singly. Single eggs measure about 0.8 mm. long by 0.4 to 0.6 mm. wide. They hatch during warm weather on the fourth day.

Larvæ. (Fig. 3, a and b.)

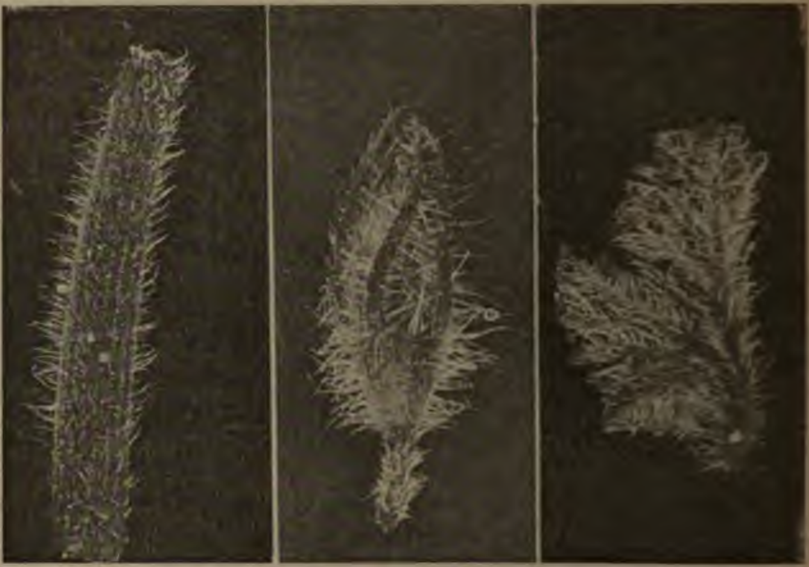
The description of the larval stages, after each molt, as originally written by Quaintance,[1] has been found by the writer to be correct and is therefore reproduced without any changes.

Larva, First Stage.—Length, 1.6 mm.; in shape, sub-cylindrical; head relatively large. Color of body, uniformly whitish; ocelli brownish black; tubercles and corneous areas, spiracles and mandibles, brownish; tips of mandibles darker, strongly toothed. Head subcordate, 0.25 mm. wide, by 0.22 mm. long; protho-

---

[1] Ga. Sta. Bul., 54.

racic shield moderately distinct; thoracic legs well developed, terminating in blade-like spine. Prolegs normal, well developed, with circle of 9 or 10 well developed hooks. Anal prolegs present, normal. Setæ arising from moderate tubercles which are surrounded by more or less well-defined corneous areas. On third abdominal segment, tubercles I, III and IV, and spiracle in almost straight dorso-ventral line. Tubercle II, ventro-caudad of I, to which it is nearer than



a b c

FIG. 2.—Egg masses of the pickle worm attached to the plant hairs of summer squash (a), 3 masses on leaf stem; (b), 1 mass on young bloom bud; (c), 1 mass on young leaf. Magnified 2½ times. (Original.)

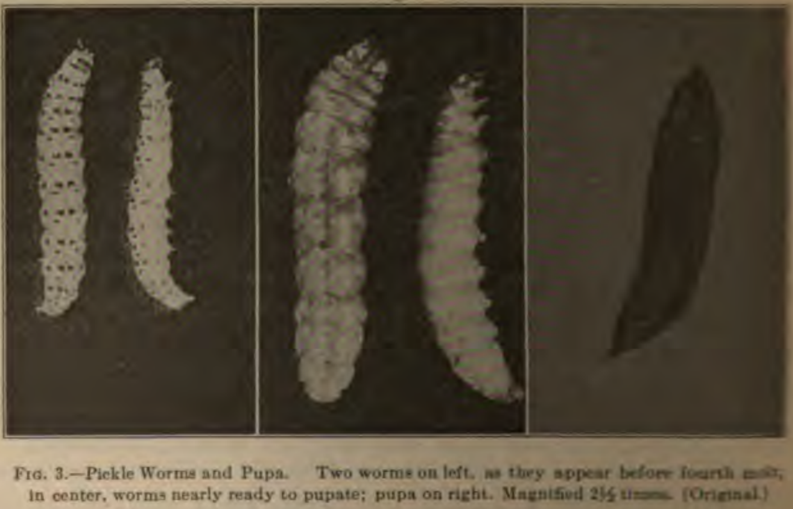


FIG. 3.—Pickle Worms and Pupa. Two worms on left, as they appear before fourth molt; in center, worms nearly ready to pupate; pupa on right. Magnified 2½ times. (Original.)

III. Tubercles IV and V approximate, though in distinct corneous areas. Tubercle VI, absent. Tubercle VII, with normal position, composed of two somewhat separated setæ. Tubercle VIII, present, on inner side of proleg. On body segments 3, 7, 9 and occasionally 2, setæ arising from Tubercle III, on each side, very long. Setæ on abdominal segments dorsad of spiracles, on each side somewhat spatulate at tip; ventrad of spiracular line setæ acute. Setæ of Tubercles II, V, and cephalic one in VII, but moderately long.

Second Stage.—Length, about 2.5 mm.; body tapering slightly caudad and cephalad; color of body whitish, the large corneous areas surrounding tubercles distinctly brown and more or less circular. Head light brown; ocelli dark brown; prothoracic shield and mandibles brown. Tubercles as in stage I, except VI, which is now present, about equidistant between IV and V, and VII. Tubercle VII, now with three setæ. In IV and V, the brown corneous areas have coalesced, though the setæ are not closer together than in First Stage.

Third Stage.—Length about 4 mm. Head about 0.81 mm. wide, by 0.64 mm. long, subcordate, brownish. Ocelli, mandibles, margin of prothoracic shield, and corneous areas of body, brownish black. In this and the Fourth Stage, the brownish black or black corneous areas occurring in more or less transverse rows, across the body, give such a conspicuous marking that any one should be able to distinguish larvæ of this species from those of *Diaphania hyalinata.* The larvæ of this latter species have two longitudinal subdorsal whitish lines and are of a pronounced greenish color; these larvæ, also, are more slender, and considerably more active when disturbed, wriggling out of a leaf, much like larvæ of the grape leaf folder (*Desmia Maculalis*).

Fourth Stage.—Length about 10 mm. Head about 1 mm. wide, by 0.96 mm. long; rather squarish, though with deep V-shaped indenture above. Body, void of food, whitish in color. Corneous areas, large, rounded, shiny black; prothoracic shield margined with black. Setæ as in previous stage.

Fifth Stage.—(Immediately after fourth moult.) Length about 15 mm. Head 1.6 mm. wide, 1.6 mm. long, sub-circular. Color of body, whitish; the distinct black transverse spots of earlier stages are lost in the fourth moult, and these, in the last stage, take a faint brownish tinge, scarcely noticeable in contrast to the color of the body. Spines and tubercles as in earlier stages.

Full Grown Larva.

A full grown pickle worm, as taken gorged with greenish colored food, is greenish to yellowish green in color, and measures from five to seven-eights of an inch in length. The feet and prolegs are lighter, with claws of feet brown. Head and prothoracic shield yellowish brown, with mandibles and ocelli dark brown. The skin is somewhat transparent and the pulsations of the dorsal tube or "heart" may be plainly seen along the back. Larvæ vary somewhat in color from whitish to yellowish or greenish, depending on the amount and character of the food matter within them. Many larvæ, after leaving the food preparatory to pupation, assume dorsally a dull, coppery color—others retain the normal coloration.

Cocoon.

Preparatory to pupating the full grown worm spins a scanty white silken lining in the fold of some leaf, usually on the wilted or dying foliage. In this shelter they assume the pupal stage.

Pupae. (Fig. 4.)

The pupa is at first pale green, but soon become rather uniformly brown, with leg and wing shields lighter. If partly exposed to the light they become very dark brown. The head end is bluntly pointed, while the caudal end is acute and bears a group of strong, short spines, curled at the tips, which serve to hold the pupa in its cocoon. The length of the pupa varies from one-half to nearly three-fourths of an inch. Fig. 4 shows their general shape and appearance. In this stage under average summer conditions they remain between eight and nine days, or all winter if they represent the last generation.

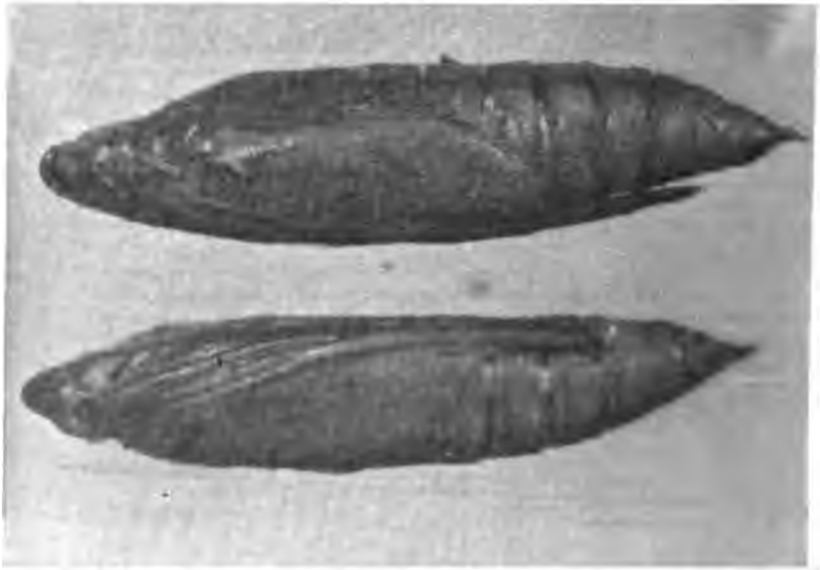


FIG. 4.—Pickle Worm Pupæ. Above, view of pupa from left side; below, partial view of ventral aspect. Magnified nearly 7 times. (Original.)

Adults. (Fig. 5.)

The adult is a somewhat striking-looking moth. The wing expanse varies from one inch to nearly one and one-fourth inches, and the length of the head and body, including the brush terminating the abdomen, is nearly five-eighths of an inch. The general color above, of body and wings, is yellowish brown, with an iridescent purplish reflection. The front wings show an irregular semi-hyaline area of a yellow tinge, situated somewhat nearer the tip than the base. On the hind wings the inner two-thirds is of the same semi-transparent yellow tinge. These markings are well shown in the illustration. The lower surface of the wings shows the same markings, but the brown color is less brilliant. The thighs and breast are silvery white, while the lower side of the abdomen and the legs are more of a tawny color. The antennæ are very slender and nearly as long as the body. The eyes are brownish-black. The prominent labial palpi are brown laterally and silvery white beneath. In both sexes, the abdomen terminates in a prominent brush formed of flattened, more or less curved scales which are yellowish near the base and darker toward the tip. This brush can be partially withdrawn so that it is not conspicuous. In the female the brush is smaller and the individual scales flatter and more curved than in the male. In other respects the sexes are difficult to distinguish, except when the female is heavy with eggs.

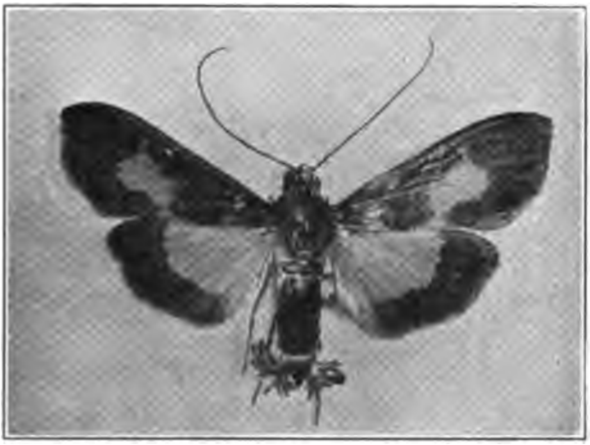


FIG. 5.—Pickle Worm Moth. Magnified 2½ times. (Original.)

EGG LAYING AND HATCHING OF EGGS.

Eggs are laid at night, probably after midnight, since the moths seldom fly before that hour. Clusters of from two to four eggs, occasionally six or seven, are usually placed on buds, flowers, terminal stems, and tender portions of the foliage, although they have been observed on older leaves when the plants are scarce. The writer has never seen them on the fruit of cucurbits. Many of the eggs are attached to the plant hairs, as shown in Fig. 2, in which case the eggs often look as though they had been impigned over the point of the hair. They are often so situated on the large plant hairs of the stems and buds of summer squash, and when so situated the egg mass assumes a globular shape. In other cases the eggs are placed loosely among the plant hairs and are often laid in flat masses on the surface of the leaf or stem. The eggs do not appear to be glued and can be dislodged without injury in most instances.

Shortly before hatching, which occurs when the egg is about three and a half to four days old, movement of the strong, dark mandibles of the larva can be seen through the egg-shell. For an hour or more before the larva emerges these jaws are frequently working in an attempt to cut through the shell. When an opening is made it is enlarged until the thoracic legs can be thrust out to gain a foothold and then the larva sometimes crawls out in a minute or two, or may slowly emerge while taking frequent rests. In masses of several eggs one may be hatched four or five hours before the last.

LARVAL DEVELOPMENT AND HABITS.

The larvæ immediately after emerging from the egg shells crawl rapidly about if confined on a small area not suitable for food, but soon commence to feed when a suitable place is found. They pay no attention to the empty egg shells. Before feeding they usually clean and straighten out the hairs scattered over the body by drawing them between their mandibles. Within a few hours after hatching the little larvæ may be completely buried in the soft tissue of the bud or fruit on which they commence to feed. Only a comparatively few reach the fruit until after they are a few days old and have passed at least the first, and usually the second molt. In large squash buds and blossoms (Fig. 6) the worms frequently become full grown and do not emerge until ready to pupate. In the smaller buds of cantaloupes and cucumbers they often feed until about half grown, and then move to the fruit. In other cases they burrow from the terminal bud clusters down into the stem and there complete their growth. In other words, these worms are nearly always feeding where poisons applied to the surface of the plant would not reach them.

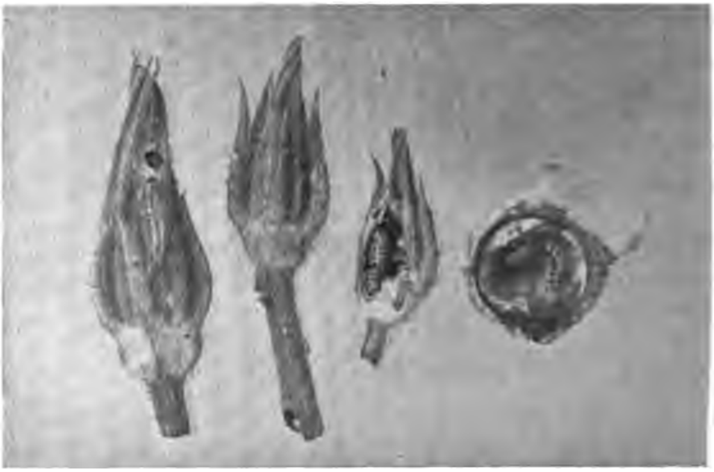


FIG. 6.—Pickle Worm Injury. Three squash buds on left; on right, very young squash cut open to expose worm within. Slightly reduced. (Original.)

During normal July or August weather, the rate of larval development is from twelve to sixteen days from the time of hatching to pupation. The last two to three days are spent in completing the lining to their pupal home, which is generally a curled up portion of a leaf, and in resting before assuming the pupal stage. As a general rule larvæ cease feeding three days after passing their fourth molt, spend a part of one day in constructing their cocoon, and then rest for a day or two before assuming the pupal stage.

In the following table is shown the rate of development in relation to the number of instars, which are marked by the molting of the skin which occurs five times.

1st Instar.—From hatching to 1st molt requires about	2½	days.
2d Instar.—From 1st molt to 2d molt requires about	2	days.
3d Instar.—From 2d molt to 3d molt requires about	2	days.
4th Instar.—From 3d molt to 4th molt requires about	2½	days.
5th Instar.—From 4th molt to 5th molt (changing to pupa) about	5	days.
	—	
Average time for hatching to date of pupation about	14	days.

The above is an average time required by the pickle worm to grow to maturity and change to the pupal stage. This estimate was determined by observing and recording the rate of growth of about fifty individuals of which the individual record of fourteen is shown in the following table:

DURATION OF LARVAL AND PUPAL STAGES.*

(Nearly all the molts and emergence of moths occurred at night. Dates below refer to when molts and moths were found.)

Record No.	Date of Hatching.	Date of First Molt.	Date of Second Molt.	Date of Third Molt.	Date of Fourth Molt.	Date of Making Cocoon.	Date of Fifth Molt. (Pupation.)	Total days of Larval Stage.	Total days of Pupal Stage.	Moth Emerged.
2	August 9	August 11	August 14	August 17	August 20	August 23	August 25	16 days	8 days	September 2
3	August 10	August 12	August 14	August 16	August 18	August 22	August 24	14 days	8 days	August 31
6	August 10	August ..	August 14	August 15	August 17	August ..	August 22	12 days	10 days	August 31
9	August 11	August 13	August 15	August 17	August 19	August 23	August 24	13 days	8 days	August 31
13	August 12	August 14	August 15	August 17	August 19	August 23	August 24	12 days	9 days	September 2
16	August 13	August 15	August 17	August 19	August 21	August 24	August 26	13 days	8 days	September 3
19	August 13	August 15	August 17	August 19	August 22	August ..	August 27	14 days	Died	....
25	August 20	August 22	August ..	August 25	August 28	August 31	September 1	12 days	10 days	September 11
26	August 21	August 24	August 26	August 28	August 30	September 3	September 5	15 days	10 days	September 16
29	August 21	August 24	August ..	August 27	August 29	September 4	September 5	15 days	10 days	September 15
31	August 22	August 24	August 26	August 28	August 30	September 4	September 5	14 days	11 days	September 16
33	August 21	August ..	August 25	August 27	August 29	September 2	September 3	13 days	11 days	September 14
34	August 22	August 24	August 26	August 28	August 30	September 2	September 4	13 days	10 days	September 14
35	August 22	August 25	August 27	August 29	August 31	September ..	September 6	16 days	11 days	September 17
							Averages ...	13 5-7 days	9 7-13 days	

---

* Record made in 1900.

From the above table it is seen that the larvæ take from twelve to sixteen days to reach maturity and pupate. Fourteen days is certainly a fair average for all the individuals whose record was secured. Later in the season when cooler weather prevails the development is considerably retarded. Scarcity of suitable food also induces much slower growth.

Pickle worm larvæ are readily recognized until after the fourth molt by the transverse rows of blackish corneous areas from which the setæ arise. When the worms molt the fourth time, these spots disappear almost completely to the unaided eye, and the worms assume a rather uniform greenish or yellowish color, depending on the character of their food. Within one or two days after the fourth molt most of the worms assume a dull coppery color above, soon after which they cease to feed and commence to prepare their pupal home. The increase in the size of the worms after the fourth molt is often remarkable. Some of them more than double in size. This increase is both in length and thickness, but particularly in the latter respect.

The coppery color of most of the full grown worms, serves to distinguish them from the melon worm, *D. hyalinata,* which lose their characteristic white stripes a few days after the fourth molt, but never assume a coppery color.

The older pickle worms, when feeding on cantaloupes, readily pass from one plant to another or from one fruit to another, thus injuring several cantaloupes, particularly when these are nearly ripe. In summer squash they are more liable to bury themselves in the flesh and feed until grown. The same is true when they are feeding in large squash buds or blossoms. Since they show a decided preference for squash buds and blossoms, as well as the squash itself, the grower can protect his cantaloupes to a great extent by using squash plants as a trap crop.

FORMATION OF PUPAE.

The pupal stage is nearly always assumed in the fold of a leaf of the plant on which the pickle worm reached maturity. Sometimes the pupæ are formed in trash around the plants, and occasionally they are not enclosed in anything except the thin silken cocoon that usually lines the place in which they pupate. Evidently all the pupæ are formed above ground. Underneath badly infested squash plants, one may often find fifteen or twenty pupæ in rolls of the leaves which have dropped to the ground. It is much more difficult to find the pupæ around cantaloupe plants.

The duration of the pupal stage during the early part of September is shown on page 116, the average being practically nine and one-half days. This, however, is longer than the average time for July and August. In addition to the record on page 116, the duration of the pupal stage was determined for sixty-one individuals between July 30 and August 17, 1909. Of this number three pupated in seven days; twenty-two pupated in eight days; twenty-six in nine days; and the remainder in ten days. The average duration of the pupal stage for those sixty-one individuals was only 8.83 days, hence nine days may be considered a fair average for the month of August, or during the usual warm summer weather.

LENGTH OF LIFE CYCLE.

Normal Summer Weather.

Individuals of each generation of pickle worms show considerable variation in the time required to reach the adult moth stage. The possible extremes are shown by the following figures, taken from previously recorded records.

SHOWING POSSIBLE VARIATION IN LIFE CYCLE OF PICKLE WORM.

Minimum Life Cycle.		Maximum Life Cycle.	
	No. Days.		No. Days
Egg stage	4	Egg stage	4
Larval stage	12	Larval stage	16
Pupal stage	7	Pupal stage	11
Total	23	Total	31

The average life cycle, as shown by all records secured, is twenty-seven days as the above figures indicate. Adding to this about one week for the moths to mate and commence to deposit eggs, it appears that the generations may follow each other about every thirty-four days, or a little over one month.

HOW WINTER IS PASSED.

The pickle worms pass the winter as pupæ under or around their food plants. Probably some few crawl a short distance before pupating, but no pupæ have been found by the writer at a greater distance than about ten feet from the food plants. During the latter part of September, 1909, a late cucumber field literally riddled by pickle worms, was frequently visited for the purpose of securing worms and pupæ. There the pupæ were often found on weeds several feet from the infested vines, and would have passed the winter in that situation, had they not been destroyed.

As a remedial measure, the burning of remnants of infested plants, and the weeds and trash around these plants, is undoubtedly of great value. It should be remembered, however, that many of the pupæ are in the folds of the leaves that have fallen on the ground, and most of these will be left if the plants are simply pulled up. In other words, the trash under the plants should be raked together and burned.

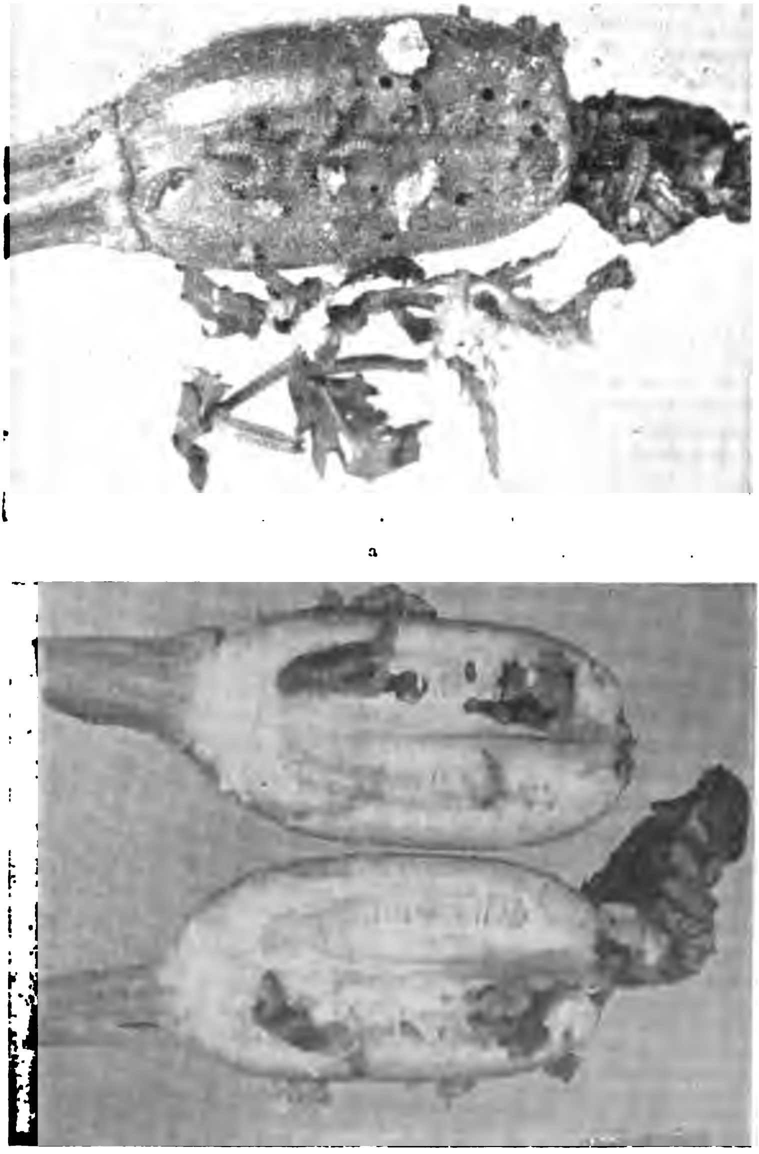


FIG. 7.—Pickle Worm Injury to Young Squash. (a), showing practically as seen in field; (b), same specimen cut in halves. Worms of all ages on this specimen. About ½ natural size. (Original.)

SEASONAL LIFE HISTORY AND GENERATIONS.

The time of appearance of the moths in the summer, from the over-wintered pupæ, is, fortunately, very late compared with many insects. In 1909, at Raleigh, moths of the first generation were discovered in the field on August 5, but empty pupæ shells were found on July 30. Judging from the condition of the worms present at that time it seems that these moths could not have emerged many days before the empty pupal shells were discovered. Granting this to be true, the eggs for this generation were laid about as early as July 1, or possibly a few days sooner. Without other records for comparison, one would judge the first generation to have commenced about July. However, in 1910, which was considered a much later season than 1909, live pupæ were found on squash plants near Raleigh on July 6, showing that the first generation in 1910 certainly commenced rather early in June.

On the following day, July 7, seven egg masses were discovered. and these hatched on July 10 and 11. Since frequent search for eggs had been made during the previous month, and none discovered. it seems quite certain that these may have been laid by an early maturing moth of the first generation.

It appears certain, therefore, that the first generation in 1909, the progeny of moths emerging from over-wintered pupæ, were missed absolutely and the empty pupæ shells found July 30, 1909, must have represented moths of the second seasonal generation.

The writer is confident that the first generation at Raleigh commences early in June for most seasons. The first generation must of necessity be very few in numbers, and easily overlooked. The manner of passing the winter shows that only a few pupæ would ordinarily survive the plowing and preparation of the land during winter or spring, followed by more or less cultivation before June 1, when the first moths may appear.

The second generation, commencing early in July is the one that frequently does some damage to cantaloupes which are maturing about July 15 to 30, but when the crop is gathered before July 15. as it is in early seasons, and especially in the cantaloupe section of Robeson and Scotland counties, pickle worms can not become numerous enough, or large enough, to cause noticeable injury. The season of 1910 was notoriously late and backward. Cantaloupe growers in Robeson County who usually commence to harvest the crop by July 4, did not commence until after July 15, and growers in that section claim that they saw more worm injury in 1910 than in many previous seasons.

The third generation always becomes very numerous and destructive. Cantaloupes that ripen after about August 1 are invariably greatly damaged. In the vicinity of Raleigh in 1910 this August injury amounted to almost total destruction in fields where squash was not present to act as a trap crop.

A full fourth generation occurs in North Carolina, but after the first one the generations are hopelessly missed and over-lapping. With sufficient food supply and warm October weather a fifth generation very probably occurs. Around Raleigh pickle worm moths continue to emerge until the latter part of October, but seldom later.

NATURAL ENEMIES.

The pickle worm does not have any important parasitic enemies in North Carolina, judging by the last two seasons work by the writer. Out of the hundreds of worms collected from the field and bred to maturity no true parasites have been reared with the exception of *Chalcis ovata,* and only one of these has been secured. This chalcid fly was also reared from a pickle worm pupa, by Ashmead, as recorded in Bureau of Entomology Bul. 14. No egg parasites have been secured. Out of several hundred eggs collected from the field, only a very few failed to hatch, and even that small per cent did not appear to be parasitized. A bacterial disease kills annually a small per cent of the nearly mature worms in the field, and in breeding jars a still greater per cent die from that cause.

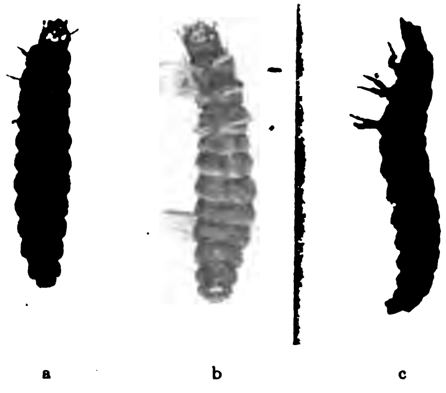


FIG. 8.—Predaceous Enemy of Pickle Worm. (a), view from above; (b), from beneath; (c), from side. Magnified 2¼ times. (Original.)

Predaceous insects kill a small per cent of pickle worms. In fields about Raleigh the tiger beetle, *Calosoma calidum,* and several ground beetles, such as the common black form, *Harpalus caliginosus,* as well as bombardier beetles of the Genus *Brachinus,* are quite numerous and doubtless prey upon the pickle worm. The writer has never seen any of these predaceous beetles actually killing the pickle worm, but they are probably of some value in this respect.

A predaceous larva of the genus *Chauliognathus* has been found in large numbers and has proved to be an active enemy of the pickle worm. The parent form is known as the Pennsylvania soldier beetle, which somewhat resembles the common firefly. The velvety dark brown or black larvæ were first observed in rather large numbers in 1909 and were reared to maturity in 1910 and identified by Schwartz as *Chauliognathus Pennsylvanicus.* (Figs. 8 and 9.)

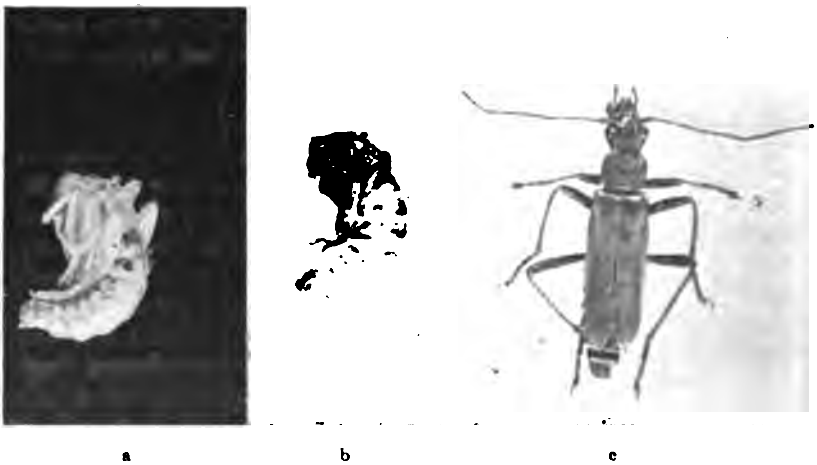


FIG.—Pupæ and Adult of Larvæ shown in Fig. 8. (a), pupa recently formed; (b), pupa darker colored, nearly ready to transform to adult; (c), adult beetle. Magnified 2½ times. (Original.)

In this vicinity this larva appears to be the most important predaceous enemy of the pickle worms. It is also of great benefit to the agriculturist by destroying other worms.

PREVENTIVE AND REMEDIAL MEASURES.

Avoiding pickle worm injury by raising early crops of cantaloupes, cucumbers, or other cucurbits, is the most profitable method for the market gardner. Previous to July 1, in all except the coastal section of North Carolina, the worms are seldom numerous enough to cause noticeable injury, but when the harvest comes during July and August severe damage may be expected. After the worms first commence to feed on the green or ripening fruit, the grower has no satisfactory means of fighting this pest. No absolute remedy is available. Such measures as collecting the worms by hand, bagging the fruit, or placing the fruit on chips and shingles may be of some value in small garden patches, but can not be adopted by the commercial grower. However, a large proportion of the annual loss may be prevented by growing summer squash as a trap plant, by destroying badly infested vines and fruit, and by general clean culture and deep plowing. Poison sprays are of little, if any value, against the pickle worm.

Squash as Trap Plant. Pickle worms evince a decided preference for the buds, blooms and fruit of summer squash. The egg-laying moths are evidently attracted by the large plants and conspicuous buds and blooms, which afford abundant food for the worms. A single squash bloom often furnishes food for two or three large pickle worms (Fig. 16), or a greater number of small ones, while several worms may mature in a small squash. Their partiality to squash blooms was demonstrated in Georgia during 1899-1901, by Quaintance,[1] whose field experiments proved that an acre of cantaloupes might be almost completely protected by four rows of summer squash. One of his experiments, made in 1901, was with one acre of cantaloupes, in which squash seed were planted at intervals of about two weeks, so that there was a succession of blooms from early in June, through July, by which time the cantaloupes had about all ripened. As the squash blooms became infested with worms, they were regularly collected, and the number of worms counted. The record shows that the number collected, commencing June 19, and ending July 30, was 5,519, or an average of over 131 worms each day. On the date of July 13, 1,289 larvæ were found in the infested buds and blooms. On the day following, July 14, a careful search was made for infested cantaloupes, and only six were found that had been bored into, out of hundreds then to be seen in the field.

During 1909-10 the writer made careful observations in many cantaloupe fields near Raleigh, all of which prove that wherever summer squash are growing beside of, or among cantaloupes, the latter are protected from pickle worms to a great extent. Especially in 1910, the value of squash as a trap plant was thoroughly demonstrated. A very conclusive test was made at the State Hospital Farm, where three or four acres of cantaloupes are regularly grown. In the spring of 1909, at the writer's suggestion, a few summer squash were planted among the cantaloupes, and resulted in a material reduction of pickle worm injury, compared with the 1908 crop.

Only one planting of squash seed was made, at the same time as the cantaloupe seed, and the squash plants were practically ruined by the worms before the middle of August, while for three weeks previous to that time, the few squash plants did not furnish enough attractive buds and blooms to protect the cantaloupes.

In 1910, however, seven rows of squash were planted the entire length of a rather long three acre field of cantaloupes. It was intended that the squash seed should be planted two weeks later than the cantaloupes, to provide abundant bloom during the latter part of June, but owing to the unfavorable season, the seed had to be replanted two and three times, and it was July 1, before many squash plants commenced to bloom. On July 7, the first infested bloom, containing ten very young worms, was discovered. No worms could then be found on the cantaloupes. The next careful examinat made July 15, showed that the squash buds and blooms were coming considerably infested. Three hills of squash (each con ing two plants) were selected, at random, and carefully exami with the following result:

---

[1] Ga. Sta., Buls. 45 and 54.

On first hill found 29 larvæ of various ages.
On second hill found 24 larvæ of various ages.
On third hill found 9 larvæ of various ages.

Total for 3 hills 62 larvæ of various ages.

Five egg masses were also taken from these three plants.

In the entire seven rows of squash, there were, in round num 400 hills, all infested to about an equal extent. By allowing only twenty larvae for each hill, it appears that the field contain on July 15, about 8,000 pickle worms of all ages.

The cantaloupes were also carefully examined on July 15, w the result that not one was found that had been eaten into, and larvæ or eggs were discovered on the buds or blooms.

This field was again visited and a record made on July 27, wh it was evident even from a casual examination, that the squa plants were becoming badly infested with pickle worms. Thr hills were again selected at random, and examined with the follow result:

On first hill found 58 larvæ of various ages, and 8 pu
On second hill found 92 larvæ of various ages, and 6 pu
On third hill found 28 larvæ of various ages, and 2 pu

Total for 3 hills 178 larvæ of various ages, and 16 pu

Egg masses representing over 30 eggs were also found on the thr hills.

These three hills represented the average condition of the enti 400 squash hills. Counting both larvæ and pupæ, the average num ber on this date for each hill was practically 65, or the enormo number of 26,000 for the entire field.

A thorough search over the cantaloupes, especially in rows a joining the squash plants, revealed only one in which a hole had bee bored. Doubtless some small larvæ were overlooked, but there wa no apparent injury. Cantaloupes in this field were just commenci to ripen, while in early seasons, the crop would have been larg harvested.

The above record demonstrates the possibilities of summer squa as a trap plant, and also shows that such plants should be systema cally searched, and infested buds and blooms destroyed, if the pick worms are to be prevented from increasing. The record rea speaks for itself. In this instance nothing was done to destroy the worms. The writer had permission to enter and examine the field at all times, but his suggestion that the infested squash plants be entirely removed and destroyed, was not followed.

On August 1, about two per cent of the cantaloupes in this field were infested with pickle worms, and from that date the injury gradually increased, until on August 12, the damage amounted to fully ten per cent.

On the same date a cantaloupe field near Method, about two miles from the State Hospital farm, was practically ruined and presented a pitiful spectacle of maturing cantaloupes utterly worthless. This field had no squash plants near by. A similar situation was observed in a field at Garner, five miles from Raleigh, and numerous other observations might be recorded, if necessary.

Successive planting of squash seed, about every two weeks, in order to provide plants with abundant buds and bloom during July and August, would doubtless enable one to raise cantaloupes for August consumption, provided the infested squash buds and blooms, and infested squash also, were collected and destroyed during July. It is the moths maturing after about July 15th that are responsible for the destructive July and August generations.

Concerning the practicability of growing summer squash with cantaloupes, without injuring the quality of the latter, there seems to be no question. Some cross-fertilization doubtless occurs, and the seed from a crop grown in this manner should not be used for planting. For seed purposes cantaloupes should be grown where they are not liable to cross with any other cucurbits.

The labor required to collect infested squash blooms is an important item, but in actual practice it could be largely avoided, while still securing the desired result, by successive plantings, and total destruction of infested squash plants before many worms reached maturity in the blooms or fruit.

Destroying Infested Plants After Harvest.—Complete removal and destruction of all infested plants and worthless fruit immediately after the crop is gathered, will serve to destroy many hundreds of pickle worms in all stages of development, and thus prevent, or lessen, the natural increase. Such work does not help the current crop, but will lessen the numbers for the following season. Plants may be destroyed by feeding to hogs, or by burning, or by means of a compost heap.

The compost heap furnishes a valuable method of disposing of remnants of garden crops, as it produces a manure that most soils require. As a means for destroying insects like squash vine borers, melon worms, pickle worms, and others, the compost heap may prove as effective as fire if the infested material is packed down and covered with earth, or decomposed compost, in order that the heat generated by the rotting organic material in the pile may destroy the larvæ and pupæ or imprison the adults which sometimes emerge from their cocoons a few days after the material is piled. Many moths may mature and escape from cucurbit plants which are gathered and dumped loosely in a pile. Burning would be better, unless the material is worked into compost as suggested. Diseased vines should always be burned, regardless of the waste in fertilizing material.

Deep Plowing and Rotation.—Turning the land by deep plowing immediately after a crop is gathered, or else in the early fall, or even during winter or spring, will serve to bury the pickle worm pupæ, and imprison most of the emerging moths. Early fall plowing is of most value, for it prevents the late generations, or at least greatly lessens their numbers.

Rotation is of some value, but by no means a certain preventive measure. It is not advisable to plant cucurbits on land that has borne infested crops the previous season, although pickle worm moths fly for considerable distances.

Poison Applications.—Poisons are mentioned last, because, in the writer's opinion, they are of little value against pickle worms. Poison dusts or sprays applied liberally to trap plants, or even to the main crop, may serve to destroy a few young larvæ that feed on the leaf buds or unopened blooms, especially when plants are badly infested, but the practice can not be recommended, except when the true melon worms are present. The latter may be poisoned more easily because of their habit of feeding freely on the foliage, as explained in the following pages.

MELON WORM.

Diaphania hyalinata. Linn.

REASON FOR COMMON NAME.

This insect is commonly termed the melon worm, although it has been referred to by different writers as the melon caterpillar, cucumber borer, squash borer, and even the pickle worm, which is now generally accepted as the common name for *Diaphania nitidalis.* The name, borer, in connection with this worm, is not exactly proper, since the worms frequently feed entirely on the foliage. At any rate, it seems best to retain the above common name, because by that term it is known by most farmers. Striped melon worm would be a very descriptive term to distinguish it from the prominently spotted pickle worm.

FOOD PLANTS AND FEEDING HABITS.

Plants belonging to the cucurbitaceous family represent the food of melon worms so far as the writer can ascertain. Squash, cymlin, cashaw or summer crook-necks seem to be the favorite food, but cucumbers, cantaloupes or muskmelons, gourds, pumpkins and watermelons may be attacked by them. The writer has never seen these worms in watermelon vines or on the fruit, but there are one or two records of such injury. Around Raleigh the principal injury occurs on summer squash, but in their absence cantaloupes and cucumbers are the favorite food plants.

Observations made during the past two seasons, principally around Raleigh, indicate conclusively that melon worms, until they become numerous, feed mainly on the foliage of summer squash, if available. When feeding on cantaloupes and cucumbers the fruit may be attacked to a serious extent, probably because the foliage of these plants is not as acceptable as that of summer squash. In States southward, where melon worms sometimes become numerous during July, which they do not around Raleigh, injury to the fruit of squash, cantaloupes and cucumbers is very serious, even though the first generation at least prefer to remain on the foliage.

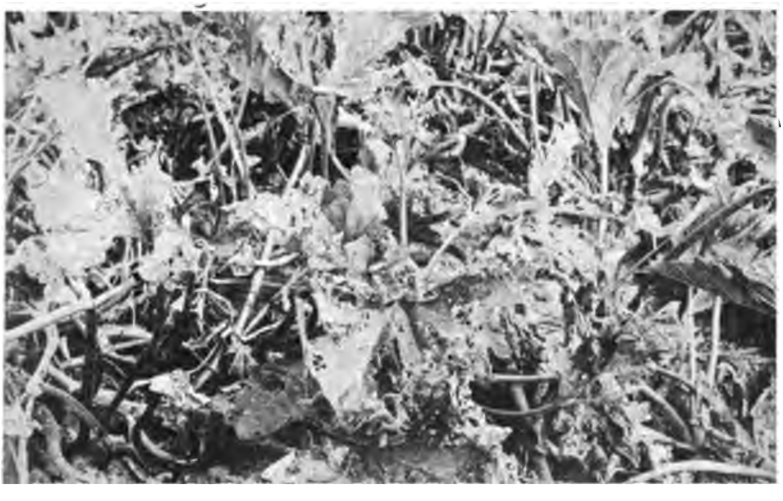


FIG. 10.—Squash Foliage Badly Eaten by Melon Worms Which Feed From the Under Surface of Leaves. Photograph taken in field. (Original.)

Larvæ only a few days old are generally found feeding in the opening bud clusters, or on the tender young leaves. While feeding they are usually slightly protected by a thin, thready web. As the worms become larger, this web is often quite noticeable on the under side of the leaves, and serves as a retreat for the worms when not feeding. Evidently most of the active feeding occurs at night, or at least after the hot portion of the day. Many worms attain full growth on the foliage, and, when numerous, cause severe defoliation, as shown in Fig. 10.

Actual injury to summer squash, cantaloupes and cucumbers is usually caused by the half-grown or nearly mature worms. Younger worms may excavate shallow cavities in the rind, or penetrate sufficiently to cause the fruit to decay. The older worms, usually bore directly through the rind, while in cantaloupes that are ripening a single worm may make several entrance holes.

Melon worms differ from pickle worms in seldom, if ever, going into the leaf stems or stalk to feed, and as a general rule, in the vicinity of Raleigh they will nearly defoliate the food plants before causing much damage to the fruit. Reports from the more Southern States indicate that the melon worms feed to a greater extent in the ripening fruit; but that habit is doubtless due to their greater numbers in those States.

HISTORY AND DISTRIBUTION.

The melon worm was first described under the name *Phalæna hyalinata* by Linnæus in 1767, but writers since that date have used the names, *Pyralis hyalinata, Phakellura hyalinatalis, Eudioptis hyalinata, Margaronia hyalinata* and *Diaphania hyalinata.* Most recent writers have placed it in the Genus Margaronia, but in Holland's Moth Book it is referred to as *Glyphodes hyalinata,* with synonyms, *marginalis,* Stoll, *lucernalis,* Hubner, and *hyalinatalis,* Guenée. It is to be hoped that *Diaphania hyalinata* will henceforth be the accepted scientific name.

The earliest mention and description of the melon worm moth was made by Linnæus in 1767. Fabricius listed it in 1794, giving its habitat as America and Asia. Poey, in 1832, published an article with a colored figure of the larva and pupa. In 1854, Guenée gave a very good description of the moth, and its distribution, together with food plants of the larvæ. Since 1875, when this insect was mentioned by Dodge as destructive to cucumbers in Florida, it has received frequent mention by various writers. During 1878-1879 the melon worm was a very serious pest in Georgia and furnished a topic for considerable discussion at the Fifth Meeting of the Georgia State Horticultural Society; held in Atlanta in 1880. During that year it was determined that the melon worms did not seriously injure cantaloupes until August, while the pickle worm was destructive in July, a condition that is generally true at the present time. Lintner, in the 11th Report of Insects of New York, 1895, gave a good general account of the melon worm, together with the bibliography to that date. Since then it has received prominent mention at the hands of Chittenden, Quaintance, Garman and others, sufficient to make it rank as a very important insect pest.

The known distribution of the melon worm includes Brazil, Hayti, Colombia, French Guiana, West Indies and Canada. Chittenden thinks melon worm to be of South American origin.

In the United States, it is more or less abundant and destructive in all the Atlantic and Gulf States from the District of Columbia, southward and westward to Texas, inclusive. It is known also in Illinois, Kansas, Ohio, Michigan, New York, New Jersey, Pennsylvania, Maryland, Delaware, and doubtless occurs in many other of the Northern and Western States. Only in the Southern States, however, is this species counted as a destructive pest. In North Carolina it does not compare in extent of injury with the pickle worm. In the opinion of the writer, this State represents about its northern range as a very destructive insect.

DESCRIPTIONS.

Eggs. (Fig. 11.)

Individual eggs are flattened, more or less oval, iridescent pearly white in color when first deposited, very thin shelled so that they assume various shapes, and are laid in masses of from two to five or six. Only occasionally are eggs deposited singly. The surface of the shell is faintly marked with raised, irregular, four, five and six-sided areas. In every respect they resemble the eggs of *Diaphania nitidalis.* When about one day old the eggs commence to assume a yellowish tinge, which becomes more noticeable as the larva within develops. Before hatching, the outline of the larva with its light brown mandibles, can be seen through the nearly transparent shell. At this stage one might possibly distinguish eggs of *D. hyalinata* from *D. nitidalis,* because the head of the latter is darker and appears more distinct through the shell. A single egg measures about 0.7 mm. in length and 0.6 mm. wide, but is variable, depending on 'where and how it is placed.

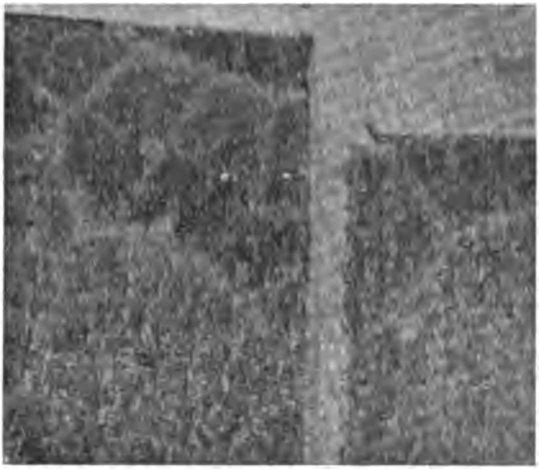


FIG. 11.—Two Egg Masses of Melon Worm on under surface of leaf. Magnified 5 times. (Original)

Larvæ.

First Stage.—Length when first hatched, 0.8 to 1.0 mm.; width of head 0.22 mm. Body, light straw color; setæ, very fine and nearly colorless, arising from tubercles arranged as in first stage of *D. nitidalis* (page 109); tubercles barely discernible; head light brown, with mandibles darker and toothed; ocelli brownish; prothoracic shield not prominent, lighter than head. Thoracic legs well developed. Prolegs well developed and normal, ending in circlet of many incurved hooks (numbering nearly forty in second stage). In this first stage the two white stripes, characteristic of the melon worms, are not discernible. The body tapers noticeably from the head posteriorily in very young larvæ. Length of the worm is nearly doubled before first molt.

Second Stage.—Length about 2.6 mm., variable. Head about 0.37 mm. wide: light brown. Ocilla, blackish; mandibles dark brown. General color of body yellowish, with rather transparent skin, through which may be seen the pulsations of dorsal blood vessel. Color greenish yellow after feeding. Two subdorsal white stripes, extending entire length of body, show faintly just after first molt, and become prominent before second molt. Body tapers slightly caudad. Thoracic legs normal, well developed. Setæ of varying lengths arising from distinct conical areas, that are smooth and shiny, but not conspicuous to naked eye. Setæ very slender, colorless.

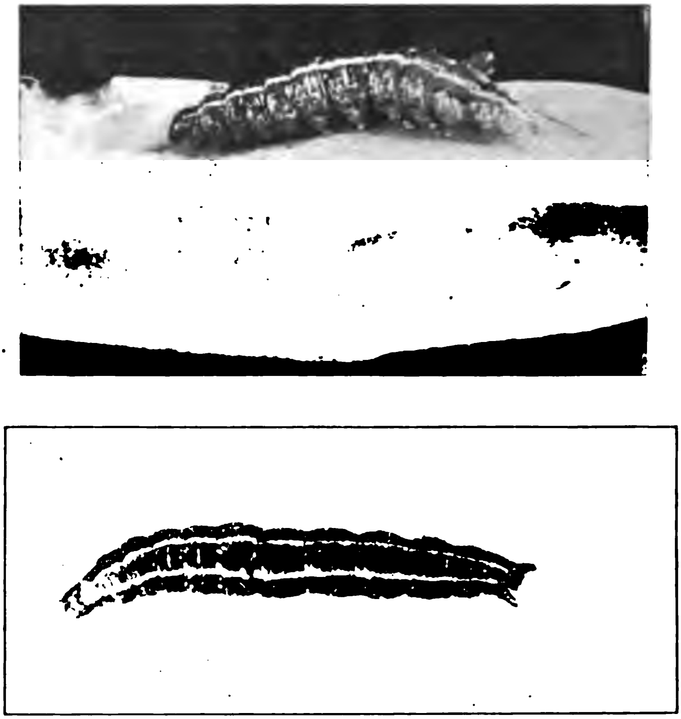


FIG. 12.—Melon Worms Photographed Alive on Piece of Cimblin. Specimens practically full grown. Magnified 2½ times. (Original.)

On the third abdominal segment the arrangement of tubercles and setæ in this and succeeding larval stages is as follows: Tubercle I, on inner edge of each subdorsal white stripe, bearing one long seta; Tubercle II, caudad of I, in center of each white stripe, bears one seta one-half as long as seta of Tubercle I and III. Tubercle III, in direct line with Tubercle I and spiracle, and situated one-fourth of the distance from latter, bears one long seta, about same length as seta of Tubercle I. Tubercles IV and V very close together, apparently forming one conical area, but showing distinct tubercle for each short seta; approximately in line with Tubercles I, III and spiracle. Setæ short, but slightly longer than seta of Tubercle II. Tubercle VI, posterior-ventrad of IV and V, situated just above base of proleg; bears one seta, rather long, but shorter than seta of Tubercle I. Tubercle VII, on outer base of proleg, bears three setæ arising close together, one of which is much longer than the other two. Tubercle VIII, on inner base of proleg, bears one short seta. This arrangement of tubercles is the same on the third, fourth, fifth and sixth abdominal segments. On segment eight, the setæ of Tubercle VII are more separated and Tubercle VIII is absent. On segment nine there are only two setæ on Tubercle VII.

Before second molt the body increases in size to a width greater than the head, which then appears small.

Third Stage.—Length about 4.5 mm., variable. Head about .64 mm. wide; color, light brown. Ocilla, blackish, mandibles brownish. General color of body greenish-yellow after feeding. Two subdorsal white stripes very prominent. Setæ fine and not easily seen. During the third and fourth and part of the fifth stage the white stripes make this worm noticeable, and easily distinguished from *D. nitidalis*, on which the transverse rows of blackish corneous areas are very prominent until after the fourth molt. Growth is rapid in this stage, so that just before third molt the head appears very narrow.

Fourth Stage.—Length about 10 mm., variable. Head about 1.04 mm. wide; color, light brown. Prothoracic shield light brown, not prominent. Ocilla, blackish. Body yellowish, with skin almost transparent, so that the character of the food taken influences its general color. Growth rapid. Conical tubercle areas smooth; shiny light green in color, but not conspicuous. Setæ as in second stage.

Fifth Stage.—(Soon after fourth molt.) Length about 16 mm., but capable of much extension or contraction. Head averages 1.63 mm. wide. Color of head light brown, mandibles darker brown, ocilla blackish. General body color yellowish prior to feeding, and two subdorsal white stripes still prominent. The larvæ now appears slender, but increase rapidly in length and thickness until, when full grown, some measure one and one-fourth inches when crawling about. Usual color is a mottled greenish-yellow. Edges of the white stripes rather irregular. Within from two to five days after fourth molt the white stripes commence to grow fainter and usually disappear about the time when the larvæ cease to feed. In some specimens these stripes almost completely disappear two days after fourth molt, while with others they persist until six or seven days after fourth molt, or just prior to pupation.

Full Grown Larvæ.

The length of full grown melon worms varies from three-fourths to one and one-fourth inches, this measurement depending largely on whether the larvæ are contracted, as when disturbed, or extended when crawling about. The general greenish-yellow color of the body is retained while the larvæ are feeding. They never assume the coppery color, characteristic of most of the full grown pickle worms. If taken just prior to pupation the melon worms are readily distinguished from pickle worms, by having a much lighter brown head, longer and more slender setæ, rather more slender body, and no sign of coppery color above. Shortly before transforming to the pupal stage, melon worms contract to about five-eighths of an inch in length and change to a light yellow or straw color.

Cocoons. (Fig. 13.)

The cocoon is formed by the grown larva spinning a scanty lining of whitish silken threads, usually in the folded or rolled edge of

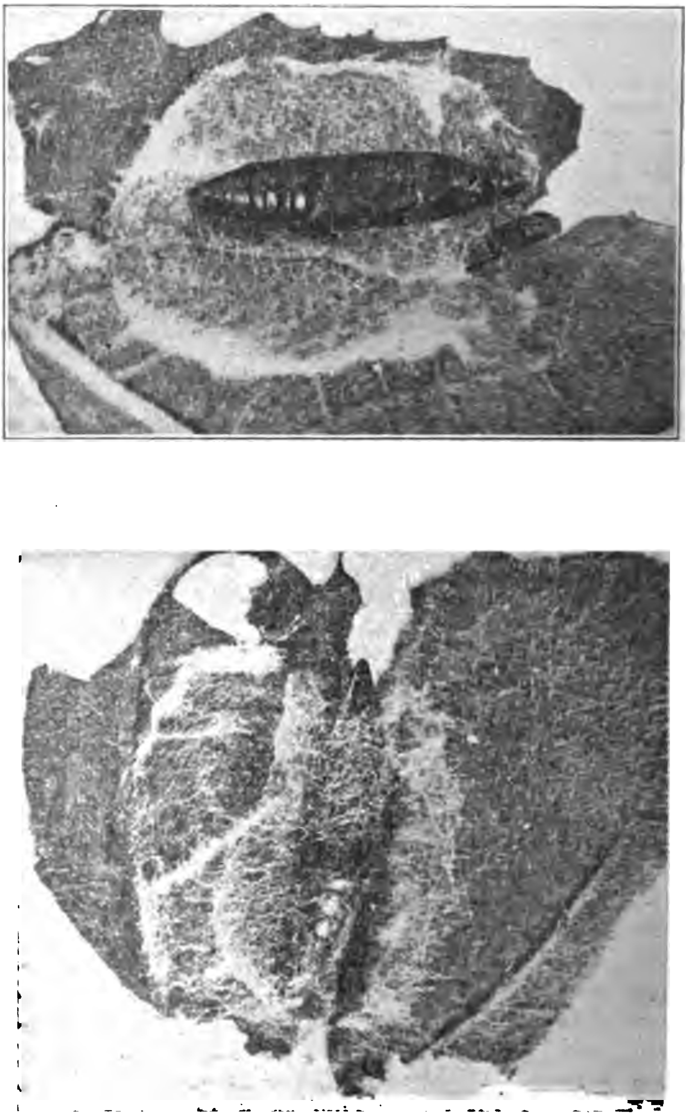


FIG. 13.—Melon Worm Pupa in Web or Cocoon. **Pupa in upper cut, entirely exposed; lower one, nearly natural appearance. Magnified 2½ times. (Original).**

me leaf. In the laboratory, in glass vials, the larvæ spin a net ork of silken threads in which they are suspended. In this meagre rotection the pupal stage is passed.

Pupæ. (Figs. 13 and 14.)

Average length about five-eighths of an inch. Color very soon fter pupation is very light brown with head and posterior end arker. Leg shields separate, extending to ninth segment. Head ather acutely pointed, somewhat flattened, dorso-ventrally. Caudal nd acute and bearing a group of a few stiff spines with strongly urved tips, which serve to secure the pupa in its web or cocoon.

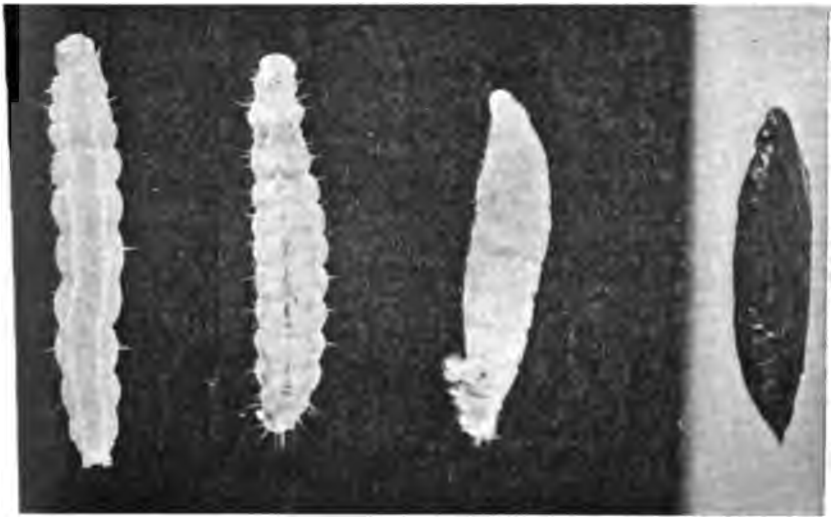


Fig. 14.—Melon Worms and Pupæ. (a), larva, fifth stage, still showing white stripes; (b), larva, fifth stage, after losing stripes; (c), pupa just formed; (d), pupa, natural color. Magnified about 2½ times. (Original.)

General color of pupa changes to brown after a few hours, and when not well protected from the light they become very dark brown, sometimes almost black. Leg shields usually remain light-brown. Spiracles show prominently before the pupa becomes dark colored. Comparing melon worm pupæ with those of the pickle worm, the former have a longer and more flattened head, and longer leg shields. They also present a rather more slender appearance, but on the whole the two species are very similar.

Adult Moths. (Fig. 15.)

The moths into which melon worms develop present a striking appearance. Width of the expanded front wings of large individuals is nearly one and one-fourth inches, while small ones measure less than one inch across; length from tip of head to tip of prominent brush terminating the abdomen is about nine-sixteenths of an inch. The front wings are of a pearly, opaque whiteness, with a peculiar iridescence, and have a broad costal band, and border equally wide, of a shining iridescent brown; the hind wings are of the same color with a brown border, diminishing toward the anal angle, which it does not reach. The anterior half of the thorax above has the same shining brown color as the wing border, while the posterior portion of the thorax and the abdomen above is pearly white, except a shining brown dorsal spot on the last segment. From beneath, the general color of body, legs and wings except the border, is silvery white.

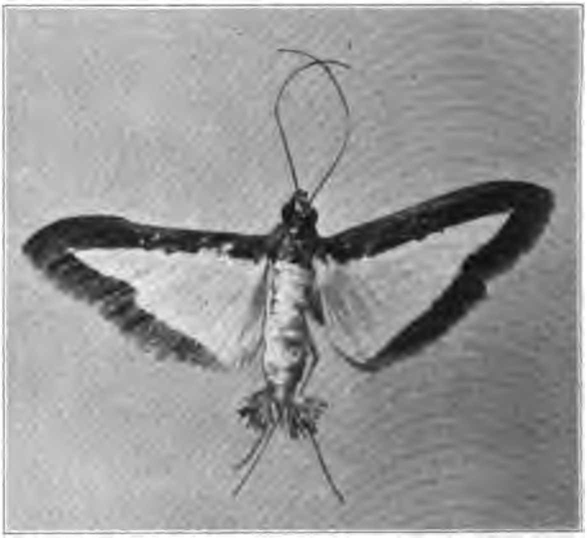


FIG. 15.—Melon Worm Moth. Magnified 2½ times. (Original.)

The conspicuous anal brush is formed of shining, elongated flattened scales, which have the basal half of a yellowish color, and the tips showing a mixture of white, brown or nearly black. This brush can be partly withdrawn, or quickly expanded to twice the width of the abdomen. The moths usually wave the expanded anal brush up and down and sideways, holding the abdomen turned slightly upward.

EGG LAYING AND HATCHING OF EGGS.

Eggs are laid rather promiscuously on the terminal bud clusters, stems, tender leaves, or sometimes on the main stalk of summer squash and cantaloupe. They have apparently never been found on the fruit. From two to six eggs are laid in masses of irregular shape, sometimes on the large plant hairs, but more commonly flat on the surface of the bud or leaf. When on the latter they are found underneath. An attempt was made in 1909 to determine the manner and time of egg laying by confining moths in a large wire screen cage, but nothing definite was learned by this attempt. The eggs are undoubtedly deposited at night, although the moths frequently fly about during the day.

Eggs hatch in warm summer weather in from three and one-half to four days. A few hours before hatching the larva may be quite plainly distinguished through the thin shell and the brown mandibles may be seen opening and closing in an attempt to cut an opening large enough to allow the larva to emerge. When this opening is effected the larva may crawl out within a few minutes, or a much longer time, sometimes nearly an hour.

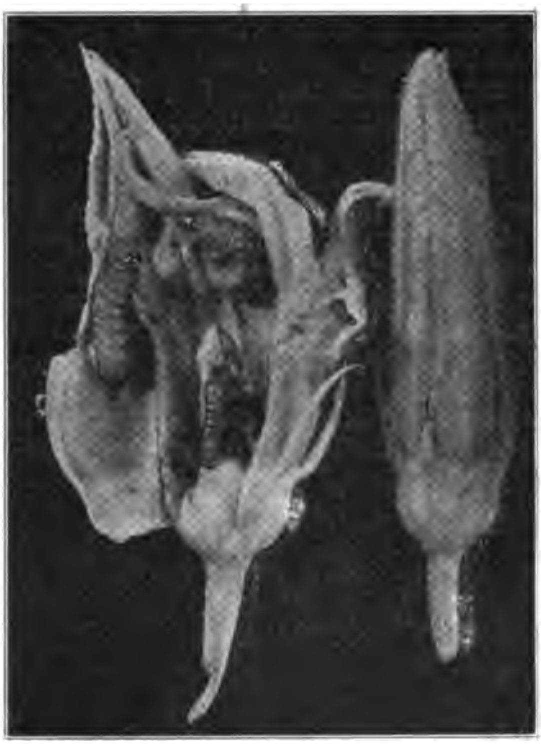


FIG. 16.—Showing How Pickle Worms Occur in Squash Bloom. Natural Size. (Original.)

LARVAL DEVELOPMENT AND HABITS.

Larvæ commence to feed soon after emerging from the egg. Some feed, until nearly or quite fully grown, entirely on the under surface of the leaves, or between the opening buds and tender leaflets, while others bore into the buds after feeding for a day or two on the outside.

Very few larvæ reach the fruit until they have attained, or passed, the third larval stage. Judging from the habits of the larvæ observed on summer squash around Raleigh, they prefer to feed entirely on the green foliage, but when tender leaves are not available, they go to the fruit, where shallow cavities may be eaten in the rind, or holes bored directly toward the interior of the fruit, where the worms feed until grown.

When feeding on the foliage or buds they nearly always spin a thin silken web to serve as a retreat, into which they back when disturbed. The movements of the larvæ of all sizes are very rapid. When disturbed they move quickly backward or forward, and often wriggle about and drop from their feeding place. The natural position of a fully grown larva, in the attitude of walking, is well illustrated in Fig. 12.

When ready to spin their cocoons (Fig. 13), melon worms seek some place between two leaves or else fold over or roll up a portion of the edge of a leaf for protection. Several hours are spent in lining this retreat, which represents the cocoon, after which they take from one to two days to transform to the pupal stage.

The average length of the larval stage is recorded in the following table, showing the development of sixteen specimens, out of over sixty that were fed and watched from the day of hatching until the adult moth appeared. Nearly all the eggs hatched and the worms molted at night, hence the dates recorded usually refer to the previous night.

DURATION OF LARVAL AND PUPAL STAGE.

Record No.	Date of Hatching.	Date of First Molt.	Date of Second Molt.	Date of Third Molt.	Date of Fourth Molt.	Date of Making Cocoon.	Date of Fifth Molt (Pupation.)	Length of Larval Stage.	Length of Pupal Stage.	Moth Emerged.
1	1909 August 12	August 14	August 16	August 18	August 20	August 24	August 25	13 days	7 days	September 1
3	August 12	August 14	August 16	August 18	August 20	August 24	August 25	13 days	7 days	September 1
11	August 13	August 15	August 17	August 19	August 22	August 26	August 28	15 days	9 days	September 6
17	August 10	August 13	August 15	August 18	August 20	August 23	August 24	14 days	8 days	September 11
35	August 20	August 23	August --	August 27	August 29	September 2	September 4	15 days	11 days	September 15
40	August 20	August 24	August 26	August 28	August 30	September 4	September 5	16 days	9 days	September 14
42	August 22	August 25	August 27	August 28	August 31	September 5	September 6	15 days	11 days	September 17
43	August 22	August 25	August 27	August 29	August 31	September 4	September 6	15 days	9 days	September 15
45	August 22	August 25	August 27	August 29	September 1	September 6	September 7	16 days	11 days	September 18
47	August 22	August 25	August 27	August 29	August 31	September --	September 6	15 days	11 days	September 17
51	August 23	August 25	August 27	August --	September 1	September 6	September 7	15 days	11 days	September 18
57	August 23	August 25	August 28	August 30	September 1	September 6	September 7	15 days	11 days	September 18
59	August 23	August 25	August 28	August 29	August 31	September 4	September 6	14 days	10 days	September 16
62	August 23	August 25	August 27	August 28	September 1	September 5	September 6	14 days	11 days	September 17
65	August 23	August 25	August 27	August 29	August 31	September 5	September 6	14 days	11 days	September 17
66	August 23	August 26	August 28	August 30	September 1	September 6	September 7	15 days	11 days	September 18
							Averages......	14 5-8 days	9 7-8 days	

From the foregoing table the length of the larval stage is seen to vary from thirteen to sixteen days, while the average of the sixteen records is fourteen and five-eighths days. It is probable that a similar record kept one month earlier, provided specimens could have been obtained, would have given a slightly lower average. The weather for 1909, during the latter part of August and September, was a little cooler than during the month of July.

PUPAE AND DURATION OF PUPAL STAGE.

The pupæ, as already stated, are usually formed in a rolled portion of a leaf, or between two leaves of the plant, on which the larvæ feed. On growing squash plants, with abundant foliage, pupæ are commonly formed in the folded edge of a green leaf some distance above the ground, but in old plants the pupæ are usually in a leaf or some vegetation underneath or close by the food plant. As a general rule the worms do not crawl far in search for a suitable place to pupate, although a few specimens have been taken from grass and weeds several feet from squash or cantaloupes. The fact that the worms do not wander far from their food plants is advantageous to the grower who may seek to destroy the worms and pupæ by burning the old worthless plants after the crop is harvested.

Concerning the duration of the pupal stage, the table on page 137 shows the average period between August 31 and September 18, for sixteen specimens, to be almost ten days. This is, however, a longer average period than that recorded for thirty-five pupæ obtained between August 8 and 18, 1909. From that number one moth appeared in seven days, thirteen moths on the eighth day, two moths on the tenth day, and nineteen required only nine days. The average pupal stage for these thirty-five pupæ was practically eight and two-thirds days, or more than one day less than the time shown in table on page 137. From all records secured the duration of the pupal stage for *D. hyalinata* is just about nine days.

LENGTH OF LIFE CYCLE.

From the foregoing records of the duration of egg, larvæ and pupa stages, the entire life cycle for a single generation in normal summer weather, is seen to be quite constant, but with possible variations as given in the following table:

SHOWING POSSIBLE VARIATION IN LIFE CYCLE OF MELON WORM.

Minimum Life Cycle.	No. Days.	Maximum Life Cycle.	No. Days.
Egg stage	4	Egg stage	4
Larval stage	13	Larval stage	16
Pupal stage	7	Pupal stage	11
Total	24	Total	31

The average life cycle proves to be twenty-seven and one-half days during August and September weather, and this length of time will not vary much for any generation except the last. By adding to the above number of days about one week for the moths to mate and commence egg deposition, the generations may follow each other every thirty-three or thirty-four days, until scarcity of food or cold weather retards the development.

HOW THE WINTER IS PASSED.

The winter is passed in the pupal stage, under conditions already described. That is, pupæ that pass the winter are not any better protected than those from which moths emerge during the summer and fall. Evidently the pupæ are always, normally, in a fold of a leaf of the original food plant, or sometimes in grass blades or weeds, within a short distance of where the worms were feeding. Judging from numerous observations made in 1909 and 1910, pupæ that are formed after about the middle of October may live through the winter, while some pupæ formed as early as October 1, do likewise, although moths are occasionally seen here after the middle of October. Some writers have suggested that the moths emerging very late in the fall, November for instance, may live over winter, but it is extremely dubtful if this ever occurs in North Carolina. If that were the case melon worms would certainly appear earlier in summer than is true at present. The over-wintering pupæ do not transform to moths before the following June or later, and it is evident that the great majority must be killed by the usual plowing and preparation of the land in winter or spring, to say nothing of probable cultivation of early crops during April and May.

SEASONAL LIFE HISTORY AND GENERATIONS.

Fortunately for growers of cucurbits, melon worms do not make their appearance until June or July in North Carolina, and seldom earlier than June in the extreme Southern States. In 1909, at Raleigh, melon worms in the second and third stages of growth were present in summer squash fields during the latter part of July, and from a number of pupæ collected August 2 and 3, nearly all of which proved to be *D. nitidalis,* one melon worm moth was bred on August 7. Two days previous three moths were captured in the field, and for the next two weeks and later moths were occasionally seen, although never more than two or three in a single day. The same year, 1909, at Morehead, Carteret County, many melon worm moths were captured in a cantaloupe field on July 19, and at that date the damage to the crop had been considerable, although much of the injury had been due to pickle worms, which were much more numerous. In 1910, melon worms were not discovered at Raleigh until August 22, when a few in the second stage were found on summer squash. Previous to that date the writer was in cantaloupe, cucumber and squash fields, three or four times each week, after the latter part of May. During that time no melon worm moths were collected, showing that they were certainly very scarce during the season of 1910.

The first generation of melon worms, judging from the record of 1909, must commence about July 1, in the vicinity of Raleigh. That is, about that date, moths emerging from over wintered pupæ, must lay eggs for the first generation. Around Morehead, N. C., in 1909, the first generation commenced as early as June 15, or possibly earlier. In the cantaloupe section of Robeson and Scotland counties there seems to be no record of melon worms before the early part of July even in extremely early seasons. If a generation of melon worms commence in North Carolina before about June 15th they must be extremely few in numbers, and certainly of no consequence.

The second generation at Raleigh in 1909 commenced early in August and at Morehead, fully two weeks earlier. An average date for North Carolina would be the latter part of July. The worms of this generation are the ones that commence to cause noticeable injury to cantoloupe, squash and cucumbers, of the medium late crops. In Robeson and Scotland counties, where the cantaloupe crop is usually harvested about July 10, this second generation never causes noticeable injury. In late seasons, such as 1910, with cantaloupes ripening about two weeks later than usual, the worms might become numerous and destructive.

The third generation is due about the middle of September, but appears too late to injure the valuable portion of the cantaloupe and squash crops. As a general rule cucurbits are dying down at that date. Worms of the third generation must commence to mature early in October and probably the majority pupate and transform to adult moths for a fourth generation, although when the food plants are nearly all dead before October, as is usually true, there is not much chance for a fourth generation, and it is doubtful if a full one develops. Parasites are also very beneficial by destroying many of the mature worms and pupæ of the fourth generation.

Google

All natural forces appear to work against any large number of melon worm pupæ living through the winter, and if the growers of cucurbits will assist nature by destroying the worms and pupæ on and around infested plants, there is no reason why this insect should ever become very destructive.

NATURAL ENEMIES.

During September and October, 1909, two parasites were frequently bred from melon worm pupæ. These parasites were identified by Viereck, of the Bureau of Entomology, as *Amemphcres sp.* and *Limnerium sp.* The former was more frequently reared, but both species are of much value and together they destroyed fully one-third of the pupæ secured during October, 1909. These parasites attack the melon worms prior to pupation, but the adults were always secured from melon worm pupæ. Another quite general parasite, a chalcid fly, *Chalcis ovata,* Say, was also reared from the pupæ, in 1909. No other parasites were secured by the writer, but *Pimpla conquisitor* was reared by Comstock in 1879, and is doubtless one of the occasional parasites at the present time.

During the season of 1910, melon worms were few in number around Raleigh, as previously stated, and no parasites were secured from the few specimens that were collected. It appears highly probable that the large number of pupæ destroyed by parasites late in the season of 1909, resulted in a material setback to the melon worms during 1910. There is good ground for the assertion that serious melon worm injury, in this vicinity, is prevented by parasites.

Egg parasites were not discovered, and seem to be unknown for this species.

Predaceous enemies of melon worms may at times prove helpful, especially when the worms are working in the fruit of cucurbits. While they remain on the foliage few are destroyed by the usual predaceous insects, mentioned on page 121. A bacterial disease sometimes attacks and kills the nearly full grown larvæ.

Severe winter weather may be partly responsible for the failure of the melon worms to increase in numbers as rapidly as the pickle worms. It seems probable that natural climatic conditions prevent the melon worm from spreading much farther north, or from being anything worse than an occasional serious pest in North Carolina.

PREVENTIVE AND REMEDIAL MEASURES.

The only remedial measures of value against melon worms consist of possible poisoning for those that eat the foliage, and the use of summer squash to help protect the more valuable crops. The latter is hardly a true remedy, but more in the nature of a preventive measure. Only a brief discussion seems necessary.

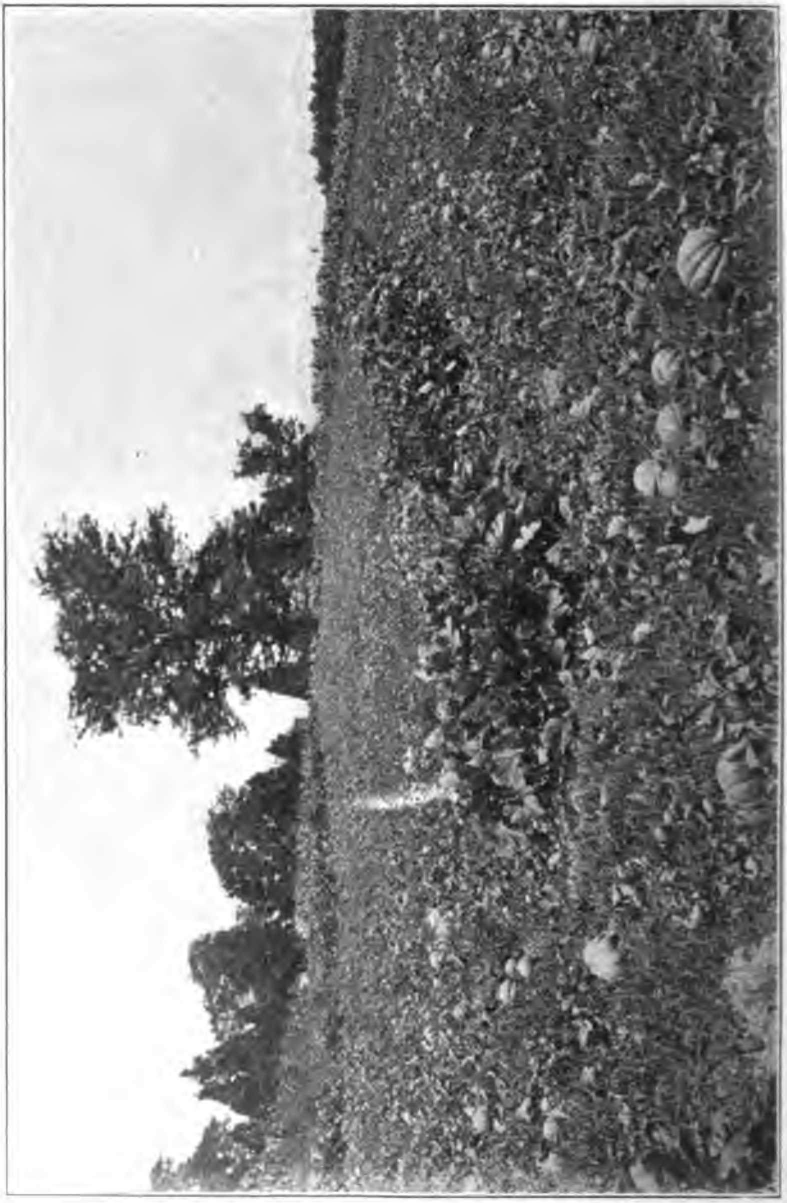


FIG. 17. Row of Summer Squash in Cantaloupe Field, Acting as a Trap for Pickle Worms. (Original.)

Trap Plants and Poison Sprays.—Melon worms apparently show a partiality for summer squash, probably owing to the fact that the egg-laying moths are attracted by the large plants. The worms do not usually occur in the buds and blooms like the pickle worms, but feed freely on the foliage and the maturing squash. Hence these plants may serve as a trap for both species. The writer has always found the melon worm on squash plants before any appear on cantaloupes or cucumbers, and in ordinary years a few squash will serve to trap the earliest worms, allowing cantaloupes or cucumbers to mature before the melon worms injure them to any noticeable extent. This is a fortunate circumstance, in that it allows the gardener to use summer squash as a trap for both species, while by poisoning the foliage and opening buds, many little larvæ may be destroyed before they are many days old.

For a poison spray, arsenate of lead, three pounds to fifty gallons of water, is most advisable, but one-half pound of Paris green with one pound of fresh slaked lime, in fifty gallons of water, may be used. The former is less liable to burn the foliage, and is more adhesive. If poison sprays are employed the trap plants should be thoroughly sprayed, at least three times, at intervals of two weeks, commencing about July 1, in the vicinity of Raleigh, or two weeks earlier in the coastal section of North Carolina.

Such treatment, supplemented by gathering infested buds, blooms, and wormy fruit, as fully discussed on pages 123 to 126, represents the most thorough method of controlling both melon worms and pickle worms.

The application of poison mixtures to a whole field of cantaloupes or cucumbers may be of some value, but it is extremely doubtful if such work would be profitable. The commercial grower can not go to that expense unless the cucurbit vines are attacked by some leaf disease that necessitates the application of Bordeaux mixture or some other fungicide. If any general spraying is made, poison should always be added in the proportion already mentioned.

Disposal of Plants After Harvest.—Prompt cleaning up and removal of remnants of infested crops will help prevent the natural increase of melon worms. This matter is sufficiently explained on page 125, to which the reader should refer.

Deep Plowing and Rotation.—These measures are also explained on page 126 and need not be repeated.

From the Gardener's Standpoint.—In localities where cucurbits have never been damaged seriously by worms, the suggestions given above and on pages 122 to 126 may seem entirely impracticable, but in the vicinity of Raleigh, where the annual loss occasioned by the two insects discussed in these pages sometimes amounts to upwards of fifty per cent, the remedial suggestions are certainly worthy of consideration.

BIBLIOGRAPHY OF MELON WORM, *Diaphania hyalinata*.

1767. Linnæus.—Syst. Nat., I, pars II, p. 874, No. 279.
1794. Fabricius.—Ent. Syst., III, pars II, p. 213, No. 311.
1832. Poey.—Cent. Lepidopt. Cubana.
1840. Westwood.—Introduc. Class. Ins., II, pp. 400-401.
1854. Guenée.—Hist. Nat. Ins., Lepidopt., VIII, p. 296.
1875. Dodge.—Field and Forest, I, page 9.
1875. Snow.—Trans. Kan. Acad. Sci., IV, p. 56.
1876. Snow.—Observ. of Nature, III, No. 5, p. 4.
1878. Mann.—Psyche, II, p. 129.
1879. Willet.—Rept. U. S. Comm. Agr., p. 219.
1880. Willett.—Proc. 5th Ann. Ga. St. Hort. Soc., pp. 7-8.
1879-80. Comstock.—Rept. U. S. Comm. Agr., pp. 218-220.
1882. Grote.—New Check List N. Amer. Moths, p. 54, No. 159.
1883. Cooke.—Ins. Inj. Orch.-Vin., pp. 301-302.
1883. Saunders.—Canadian Ent., XV, p. 56.
1883. Saunders.—14th Rept. Ent. Soc. Ont., pp. 23-24.
1883. Saunders.—Ins. Inj. Fruits, pp. 365-366.
1883-84. Edge.—Rept. Pa. State Bd. Agr., pp. 66-67.
1884. Fernald.—Kingsley's Stand. Nat. Hist., II, p. 444.
1885. Lintner.—Country Gentleman, vol. 50, p. 607.
1886. Lintner.—Country Gentleman, vol. 51, p. 733.
1887. Ashmead.—U. S. Dept. Agr., Div. Ent., Bul. 14, O. S., pp. 26-27.
1888. Riley-Howard.—Insect Life, I, p. 161.
1889. Edwards.—U. S. Nat. Mus., Bul. 35, p. 111.
1889. Campbell.—Ga. Sta., Bul. 3, pp. 45-46.
1889. Lintner.—5th Rept. Ins. N. Y., p. 320.
1890. Smith.—Cat. Ins. N. J., p. 343.
1890. Riley-Howard.—Insect Life, II, p. 376.
1891. Riley-Howard.—Insect Life, IV, p. 157.
1891. Smith.—List Lepidopt., Bor. Amer., p. 75, No. 3973.
1891. Van Duzee.—Lists Macro-Lep. Buff.-Vic., in Bul. Buff. Soc. Nat. Sci., V, p. 157.
1891. Kent.—Insect Life, III, p. 337.
1892. Moffat.—Canadian Ent., XXIV, p. 132.
1893. Howard.—Amer. Gard., XIV, No. 4, pp. 209-210.
1894. Lintner.—Country Gentleman, vol. 59, p. 721.
1894-95. Lintner.—10th Rept. Ins. N. Y., p. 503.
1895. Lintner.—11th Rept. Ins. N. Y., pp. 134-138.
1895. Comstock.—Manual Study Ins., pp. 231-232.
1896. Hopkins-Rumsey.—W. Va. Sta., Bul. 44, pp. 300, 317.
1896. Quaintance.—Ga. Sta., Bul. 31, pp. 298-300.
1896. Quaintance.—Fla. Sta. Rept., pp. 57-59.
1897. Starnes.—Ga. Sta., Bul. 38.
1897. Slingerland.—Rural New Yorker, 21 Aug., p. 548.
1898. Rolfs.—Fla. Farmer, 15 Jan.
1898. Sanderson.—Southern Ruralist, 16 Feb.
1899. Moffat.—29th Ann. Rept. Ent. Soc. Ont., pp. 101-103.
1899. Felt.—Country Gentleman, 16 Feb., p. 128.
1899. Chittenden.—U. S. Dept. Agr., Div. Ent., Bul. 19, N. S., pp. 41-44.
1899. Quaintance.—Ga. Sta., Bul. 45, pp. 42-45.
1899. Quaintance.—U. S. Dept. Agr., Div. Ent., Bul. 20, N. S., p. 59.
1899. Quaintance.—Proc. 23d Ann. Meeting Ga. State Hort. Soc., p. 52.
1900. Quaintance.—13th Ann. Rept. Ga. Sta., pp. 364-365.
1900. Chittenden.—U. S. Dept. Agr. Div. Ent., Bul. 22, N. S., p. 53.
1901. Garman.—Ky. Sta., Bul. 91, p. 41.
1901. Walker.—Ark. Sta., Bul. 69.

1902. Fulton.—Ga. Sta., Bul. 57.
1902. Surface.—Pa. Dept. Agr., Bul. 96, p. 30.
1903. Holland.—The Moth Book, p. 394.
1907. Chittenden.—Ins. Inj. Vegetables, pp. 173-175.
1908. Smith.—N. C. Sta., Bul. 197, pp. 57-58.
1910. Smith.—N. C. Sta., Bul. 205, pp. 35-38.

BIBLIOGRAPHY OF PICKLE WORM, *Diaphania nitidalis*.

1782. Cramer.—Pap. Exot. trois part. du monde, IV "371 F."
1794. Fabricius.—Ent. Syst., Tom. III, pars II, p. 228 (Habitat Austria).
1854. Guenée.—Hist. Nat. Ins.-Lepidopt., VIII, p. 299 (descr. food plants and distribution).
1869. Walsh-Riley.—Amer. Ent., II, p. 31 (injuring cucumbers at Alton, Ill., and Peverly, Mo.), do., p. 61 (at St. Joseph, Mich.).
1870. Riley.—2d Rept. Ins. Mo., p. 7, and pp. 64-70 (larva described, natural history, distribution).
1870. Glover.—Rept. U. S. Comm. Agric., p. 84 (injuring squash in Fla. and cucumbers in Mo.).
1872. Le Baron.—Prairie Farmer, V, 43.
1875. Snow.—Trans. Kan. Acad. Sci., IV, p. 56.
1876. Snow.—Observer of Nature, III, No. 5, p. 4.
1877. Packard.—Rept. U. S. Geol. Surv. Terr., Hayden's 9th, p. 772.
1877-78. French.—Trans. Ill. State Hort. Soc., pp. 199-200.
1877-78. French.—7th Rept. Ins. Ill., pp. 251-252.
1879. Comstock.—Rept. U. S. Comm. Agric., p. 219.
1882. Grote.—New Check List N. Amer. Moths, p. 54, No. 160.
1883. Cooke.—Ins. Inj. Orch.-Vin., pp. 304-305.
1883. Saunders.—Ins. Inj. Fruits, pp. 367-368.
1883-84. Edge.—Rept. Pa. St. Bd. Agr., pp. 65-66 (brief).
1884. Fernald.—Kingsley's Stand. Nat. Hist., II, Crust. & Ins., p. 444.
1885. Lintner.—Country Gentleman, vol. 50, p. 607. (From Tenn.).
1886. Lintner.—Country Gentleman, vol. 51, p. 733. (From Va.).
1886. Lintner.—3d Rept. Ins. N. Y., pp. 140-141.
1887. Ashmead.—U. S. Dept. Agr., Div. Ent., Bul. 14, p. 24.
1889. Lintner.—5th Rept. Ins. N. Y., p. 320.
1889. Edwards.—U. S. Nat. Mus., Bul. 35, pp. 111-112.
1889. Campbell.—Ga. Sta., Bul. 3, pp. 46-47.
1890. Kent.—Insect Life, II, p. 283.
1891. Smith.—List Lepidopt. Bor. Amer., p. 75, No. 3975 (listed).
1892. Moffat.—Can. Ent., XXIV, p. 132.
1893. Howard.—Amer. Gard., XIV, April, p. 209.
1894. Lintner.—Country Gentleman, vol. 59, p. 721. (From N. & S. Carolina.)
1894-95. Lintner.—10th Ann. Rept. N. Y. St. Ent., p. 503.
1895. Lintner.—11th Ann. Rept. N. Y. St. Ent., pp. 126-133. (Good general account.)
1896. Hopkins-Rumsey.—W. Va. Sta., Bul. 44, p. 300.
1896. Quaintance.—Fla. Sta., Bul. 34, pp. 292-293.
1896. Smith.—Text-book Econ. Ent., p. 311.
1897. Slingerland.—Rural New Yorker, Aug. 21, p. 548.
1898. Rolfs.—Fla. Farmer, Jan. 15.
1898. Sanderson.—Fla. Farmer, Feb. 26; Southern Ruralist, March.
1899. Chittenden.—U. S. Dept. Agr., Div. Ent., Bul. 19, N. S., pp. 41-42.
1899. Felt.—Country Gentleman, Feb. 16, p. 128.
1899. Smith.—Insects of N. J., p. 459. (Listed for N. J.).
1899. Quaintance.—Ga. Sta., Bul. 45, p. 36.
Proc. 23d Ann. Meeting, Ga. St. Hort. Soc., p. 52;
U. S. Dept. Agr., Div. Ent., Bul. 20, N. S., p. 58.
1900. Quaintance.—Proc. 24th Ann. Meeting, Ga. St. Hort. Soc., p. 41;
13 Ann. Rept., Ga. Sta., pp. 363-364.

1900. Chittenden.—U. S. Dept. Agr., Div. Ent., Bul. 22, N. S., p. 53. (Reference to occurrence in relation to weather.)
1901. Garman.—Ky. Sta., Bul. 91, p. 39. (Account of in Ky.).
1901. Walker.—Ark. Sta., Bul. 69. (Note concerning injury in Ark.).
1902. Surface.—Pa. Dept. Agr., Bul. 96. (Brief mention.)
1907. Chittenden.—Ins. Inj. to Vegetatables, pp. 171-175.
1908. Smith.—N. C. Sta., Bul. 197, pp. 44-46.
1910. Smith.—N. C. Sta., Bul. 205, pp. 29-35. (General life history and remedies.)

BULLETIN 215 JUNE, 1911

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

COTTONSEED MEAL FEEDING EXPERIMENTS WITH MULES AND HORSES

RALEIGH
EDWARDS & BROUGHTON PRINTING CO.
STATE PRINTERS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

GOVERNOR W. W. KITCHIN, *ex-officio* Chairman, Raleigh

C. W. GOLD	Raleigh	M. B. STICKLEY	Concord
E. M. KOONCE	Jacksonville	T. T. BALLINGER	Tryon
T. E. VANN	Como	N. B. BROUGHTON	Raleigh
D. A. TOMPKINS	Charlotte	O. L. CLARK	Clarkton
J. O. ELLINGTON	Fayetteville	EVERETT THOMPSON	Elizabeth City
W. E. DANIEL	Weldon	R. H. RICKS	Rocky Mount
W. H. RAGAN	High Point	O. MAX GARDNER	Shelby
W. B. COOPER	Wilmington	M. L. REED	Asheville

STATION STAFF

D. H. HILL, President of the College

C. B. WILLIAMS	Director and Agronomist
W. A. WITHERS	Chemist
F. L. STEVENS	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY	Poultryman
F. C. REIMER	Horticulturist
R. S. CURTIS	Animal Husbandman
G. A. ROBERTS	Veterinarian
R. I. SMITH	Entomologist
J. C. MCNUTT	Dairy Husbandman
J. D. CECIL	Animal Pathologist
W. C. ETHERIDGE	Associate Agronomist
B. J. RAY	Assistant Chemist
A. R. RUSSELL	Assistant in Field Experiments
F. W. SHERWOOD	Assistant Chemist
L. R. DETJEN	Assistant Horticulturist
GUY WEST WILSON	Assistant in Vegetable Pathology
T. B. STANSEL	Assistant Bacteriologist
A. F. BOWEN	Bursar
LOULA V. SHERWOOD	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS

Summary 175

Feeding Cottonseed Meal to Draft Animals 177

Former Use of Cottonseed Meal 177

Value of Cottonseed Meal 178

Nature and Composition of Cottonseed Meal 178

Preliminary Feeding 179

Feeds Adapted for Using with Cottonseed Meal 179

Amount of Cottonseed Meal to Feed 179

Method of Feeding 180

Harmful Effects of Cottonseed Meal 180

A Plausible Reason Why Work Animals Can Use Cottonseed Meal Continuously 180

Data from Practical Farmers 181

Results Obtained by Other Station Workers 183

General Results Obtained from Feeding Cottonseed Meal 185

Some Cottonseed Meal Rations 186

SUMMARY

Cottonseed meal may be used in limited quantities in rations for work stock with satisfactory results, although in some cases animals will refuse it even after repeated attempts to feed it.

It should never be undertaken to feed cottonseed meal alone. It is a very concentrated feed, and for this reason it should be used only as a supplement to carbonaceous and fat producing feeds.

The meal should always be fed with some finely divided concentrate, such as corn-and-cob meal, wheat bran or brewers' grains. The more thorough the mixture of cottonseed meal with the basal feeds the more satisfactory the results will be.

The amount of cottonseed meal to feed daily should rarely exceed two pounds per animal. A safe guide to follow will be to feed one-fifth of a pound of the meal for every hundred pounds live weight. Draft stock exceeding one thousand pounds in weight to any great extent may use two and one-half, and possibly three pounds per day in exceptional cases.

Based on the ration for a work animal of average weight, the amount of meal fed should not exceed fifteen per cent of the total ration by weight. As a general thing the results will be more satisfactory if only ten to twelve per cent of the ration is cottonseed meal.

The results obtained by the writer during three years experimental work show that no ill effects will arise from the use of cottonseed meal if it is used with judgment, however, if it is unduly increased, it will not only be refused but will injure the condition and working efficiency of the animals.

The chief thing in mixing a cottonseed meal ration is to use it in connection with feeds which can be thoroughly incorporated with it, thus avoiding any quantity of the meal sifting through the ration to the bottom of the feed trough. Wheat bran is excellent for this purpose, although its use increases the cost of the ration.

Only bright, fresh, light-colored cottonseed meal should be used. Meal which is of a dark yellow color is most likely to be old and somewhat musty. This stale condition of the meal is no doubt at times responsible for animals refusing it.

Cottonseed meal is an excellent laxative and for this reason it is desirable to feed with corn, aside from the fact that it furnishes the deficiency of protein in corn.

The effect of the meal on the coat of the animal is to make it smooth and glossy, having the same effect in this respect as linseed meal.

The present price of cottonseed meal, which will average about $30.00 per ton, precludes any reduction in the cost of the ration. Its principal value must be derived from the beneficial effect on the coat, condition and digestive system of the animals and in the enhanced value of the manure.

FEEDING COTTONSEED MEAL TO DRAFT ANIMALS.

By R. S. Curtis.

Former Use of Cottonseed Meal.

There has been considerable diversity of opinion regarding the use of cottonseed meal as a feed for draft animals. On the whole, however, the weight of evidence seems to be in favor of this feed for work stock when it is fed with judgment. The writer has found as a result of three years experimental work, that there is no good reason why more cottonseed meal should not be used for this purpose. While the economy of the ration containing the meal will vary under different conditions, so far as the actual use of the feed is concerned in limited quantities in the daily ration, there seems to be no question. When fed in quantities ranging from ten to fifteen per cent of the total ration by weight, it will generally be eaten satisfactorily without any observable detrimental results. At least at the conclusion of experiments extending over a period of three years there was no evidence antagonistic to the continuous use of moderate quantities of this concentrate from the standpoint of health. In one or two cases during the preliminary part of the work some of the animals were impaired temporarily. This was caused, however, by making the substitution of the meal for corn on the basis of food nutrients. For example, in one experiment one pound of cottonseed meal was substituted for three pounds of corn in the ration. This was found to be impractical. Otherwise, at no time during these experiments was the meal fed in unusually large quantities. The final experiments were planned with the idea of keeping below the maximum safe quantity rather than above this amount.

The writer is of the opinion that much of the prejudice against feeding cottonseed meal to draft animals is the result of feeding the meal to excess or from influences based on the detrimental results obtained from feeding the meal to other animals, especially swine.

If cottonseed meal is not used with judgment, it will be far better not to use it in the ration. This does not necessarily mean that special precaution must be taken in order to prevent fatalities as any concentrated feed of this nature must be fed judiciously if the most satisfactory results are to be obtained. It should be kept in mind at all times that cottonseed meal should be used as a supplementary feed, and should never be used as the principal component of the ration for work stock. For some animals, such as beef cattle intended for slaughter, this plan may be followed but not with animals having a continued field of usefulness. In this connection it is not the intention to convey the impression that cottonseed meal should be used to the exclusion of other supplementary concentrates. Considering the feed and fertilizing value of the meal, however, it is thought that a wise use of it in the rations for working animals will be a means of retaining on Southern farms some of the fertility of the by-product which is sold in large quantities in other parts of the country.

Nature and Composition of Cottonseed Meal.

Cottonseed meal is valued as a feed principally because of its high protein content and for this reason it is desired in the ration for work animals which are generally fed on corn exclusively.

Cottonseed meal is one of the most concentrated commercial feeds on the market containing on the average the following nutrients:

TABLE 1.—GIVING THE PERCENTAGE COMPOSITION OF THE NUTRIENTS IN COTTONSEED MEAL.[1]

Water	Ash	Protein	Carbohydrates	Fat
8.5	6.5	41.0	35.0	9.0

Unadulterated cottonseed meal should have a light yellow color and a sharp, nutty odor. If the meal is dark or reddish in color, the presumption is that it is old or it has been adulterated with ground cottonseed hulls which materially reduces its feeding value especially for horses and mules.

Value of Cottonseed Meal.

The reasons for feeding cottonseed meal to work animals may be considered from two viewpoints. First, work stock should be supplied with a ration which will furnish, without the loss of any nutrients, the necessary energy for doing the work required of them. The corn ration which is used largely as a feed for this class of stock is too carbonaceous for economical results, and especially for growing animals. It is necessary to feed a corn ration in excess of the actual needs of the animal in order that the required amount of protein material may be furnished.

Cottonseed meal contains a large amount of protein, and for that reason it is well suited for supplementing corn in a ration for work stock. Theoretically the quantity of meal could be varied in the ration and made to suit the different stages of development in the animal from the growing period to maturity. In practice, however, the amount which can be used successfully is limited. When the ration is properly compounded, the extra quantity of protein needed can be supplied largely from cottonseed meal, and in so doing the ration is made more efficient than a corn ration.

The second reason for feeding cottonseed meal to work animals is to secure its feeding value and at the same time retain in the manure a large percentage of its fertilizing value. The writer considers it a business proposition to secure when possible the feeding value of cottonseed meal before it is used for fertilizing purposes. Each year, the Southern States export about 1,000,000 tons of cottonseed products which should be used here. The work animals in this State alone if fed the quantity of cottonseed meal recommended would consume practically one-tenth of the entire amount of these products exported.

---

[1] North Carolina Experiment Station Chart—C. B. Williams.

Feeds Adapted for Using with Cottonseed Meal.

Communications from various sources state that work animals will eat cottonseed meal readily either alone or mixed with other feeds. This may be true in isolated cases but such is not uniformly the case according to the experience of the writer. It is possible that animals which have been reared on cottonseed meal from early life may eat it more readily than otherwise. This seems plausible, but experimental results show that animals which have cottonseed meal suddenly placed in the ration do not always adapt themselves to the change even after continued trials.

By supplementing the meal with such feeds as wheat bran, a great many difficulties will be overcome. Wheat bran is considered as one of the best available complementary feeds. Brewers' grains, crushed oats or whole oats, corn-and-cob meal and cut hay are also very useful for this purpose. Crushed or ground husk corn is claimed by some to give splendid results as a basal feed for using with cottonseed meal. The chief thing in feeding the meal is to secure a basal feed which can be thoroughly mixed with it. This lightens the ration and at the same time overcomes the odor which seems disagreeable to many animals. Louisiana planters use quite large quantities of black strap molasses in their cottonseed meal rations for work animals. They attribute their success in feeding the meal largely to the molasses. They state that cottonseed meal is rarely if ever refused by work animals when it is properly incorporated with the basal feed and the whole thoroughly mixed with molasses.

Preliminary Feeding.

In using cottonseed meal in the ration for the first time, the quantity fed should be limited for several weeks. Not over one-fourth of a pound should be given at each feed for the first two or three weeks. This is essential, as overfeeding may be, and no doubt has been responsible for the ill effects following the use of cottonseed meal both with work animals and other live stock. Besides the concentrated nature of the meal, its laxative effect should be closely watched, as overfeeding may cause considerable trouble of this kind. If the animals fed on the meal are not placed on a full feed of two pounds before the end of six weeks, it will be far better than to increase it more rapidly. By observing the above precautions success will be secured where a more rapid introduction of the feed in the ration might cause failure.

Amount of Cottonseed Meal to Feed.

The amount of cottonseed meal to feed should be determined by the size of the animal; the character and severity of the work; the composition of the basal concentrated feeds, and the roughage used. Although it is not likely, if the main concentrates contain a larger percentage of protein than corn, the most commonly used feed, it will not be necessary to use as much cottonseed meal as otherwise. Also, if the roughage consists of clover or cowpea hay or some other nitrogenous roughage, it will not be necessary to use the maximum amount of cottonseed meal recommended.

Method of Feeding.

The method of feeding cottonseed meal will depend somewhat upon the amount used. If the largest amount that can be safely fed is used it will be better to distribute it equally in the three daily feeds. If a smaller quantity is used, for example one pound daily, it may be given in two feeds, preferably the morning and night portion of the ration. The meal should be thoroughly mixed in the main part of the feed, as it might otherwise sift out and gradually collect in the feed trough and ferment.

Harmful Effects of Cottonseed Meal.

The harmful effects from feeding cottonseed meal to work stock are largely due to overfeeding. While the exact cause of the toxicity has never been determined, the meal may be fed in moderate quantities to some farm animals for limited periods with satisfactory results. Its use generally, however, is not recommended, especially for calves and swine, although for dairy and beef cattle and working animals it can be fed without any of the ill effects which frequently follow its use with calves and swine. When fed to work stock in the quantities recommended it can be used without any anticipation of disastrous results.

A Plausible Reason Why Work Animals Can Use Cottonseed Meal Continuously.

It is a well known fact that dairy cattle can use moderate quantities of cottonseed meal in their rations without suffering any of the ill effects which characterize its use with other animals. Even working oxen will eat quite large quantities of the meal apparently without any ill effects. It will be noticed that any class of stock which does not use the feed assimilated for increasing the body weight can usually continue to take the meal in limited quantities without harm. This is well illustrated by the character of the product obtained from dairy cattle and the work obtained from draft stock. While the question may arise regarding the proportionate amount of cottonseed meal actually fed to different classes of stock and the weight of the animals being fed, it might be stated that where pigs have been fed cottonseed meal, cases are on record where those receiving a small amount of meal, one-fourth of a pound daily died in a short period. On the other hand, pigs of the same weight fed one pound of meal daily, continued to live for ninety days, at which time they were discontinued, apparently in normal condition. For this reason and other peculiarities attending the use of cottonseed meal, there seems to be some foundation to the statement that the amount of meal which can be fed continuously will depend somewhat on the character of the product made or the work done by the animal using cottonseed meal.

Any class of animals which use the meal in quantities sufficient to increase their weight materially, namely, beef cattle, and swine, will eventually reach the period when partial or entire blindness, staggers or even death may result. From whatever sources the writer has received reports of these troubles with horses or mules, it has been found that more meal was being used in each case than is conservatively recommended for the average draft animal.

Data from Practical Farmers.

In Table 2 some important data is given from men who have had considerable experience in feeding cottonseed meal to draft animals. Their observations were based upon extensive trials with a large number of animals, covering a period of several years. A number of additional names might be added to the list, but this is not felt to be necessary since the results obtained by them were practically the same as those reported in the table.

TABLE 2.—SHOWING THE RESULTS OBTAINED FROM FEEDING MULES AND HORSES ON COTTONSEED MEAL BY PRACTICAL FARMERS IN NORTH CAROLINA AND LOUISIANA.

Name and Address of Feeders	List of Questions Submitted and Answers Received.								
	Number Horses Fed Cottonseed Meal	Number Mules Fed Cottonseed Meal	Length of Time Fed in Years	Pounds Cottonseed Meal Fed Per Day	Feeds Given with Cottonseed Meal	Pounds Cottonseed Meal Fed in Beginning	Animals Ever Refused Cottonseed Meal?	Detrimental Influences Noticed?	Expression of Results Obtained
The Leon Godcheaux Co. Ltd., Reserve, La.	None	300	5	1½—3	Corn-and-cob meal, brewers' grains, and molasses.	¾	Not when fed with molasses	None	Very well impressed
G. B. Reuss, Hohen Solms, La.	10	150	2	1	Ground corn and molasses	1	No	None	Very satisfactory.
Thos. H. Rogers, Thibodeaux, La.	12	120	5	¾	Ground husk corn and molasses	½	Only when cottonseed meal is fed alone	None	Satisfactory feed with molasses
C. S. Matthews, Matthews, La.	25	250	1	1	Ground corn and molasses	1	Only when fed in large quantities	None	....
John R. Todd, Foster, La.	22	154	1	10% of ration	Oats and corn	......	No	Blindness	....
John T. Moore Planting Co., Schriever, La.	15	150	13	2—2½	Corn-and-cob meal, rice bran and molasses	½—1	No	None	Excellent results
J. J. Jacobs, Convent, La.	6	82	3	2½—3	Brewers' grains, corn and oats	2	No	Overheating and blindness	Satisfactory
Beaufort Lumber Co., Shelmerdine, N. C.	....	48	2 mo.	1½	Cottonseed hulls	Sm'l am't	Sometimes when first fed	....	Financial saving
Frank P. Shields, Scotland Neck, N. C.	15	60	3	1½—2	Corn	½	No	Possibly affects eyes	Satisfactory
John Dymond, New Orleans, La.	10	50	5	2	Cut hay and molasses	Full ration	At first only	None	Very satisfactory
R. T. Gibbons, Baton Rouge, La.	5	50	10	2	Crushed corn, oats, cut hay and molasses	¼	No	None	Satisfactory
G. W. Lentill, Bunkie, La.	2	46	6 mo.	2	Corn and molasses	2	At first only	None	Satisfactory

It will be noticed from the results given in Table 2, that the amount of cottonseed meal fed ranged from three-fourths of a pound to three pounds per day, with a daily average of about two pounds. In every case the best results were obtained when the meal was mixed with a feed which had previously been crushed or ground or which was naturally in a finely divided condition. Oats are the best adapted of the farm grains for mixing with the meal without further alteration. In a number of cases reported, oats were used as a part of the basal feed. The Louisiana planters in almost every case mix their feeds as suggested and add from six to twelve pounds of black strap molasses, which seems to materially improve the cottonseed meal ration both in palatability and efficiency. The parties furnishing the data for this table claim that cottonseed meal is not often refused by horses or mules when it is thoroughly mixed with the other basal feeds. This is especially true if molasses is added to give palatability to the ration. In two cases shown in the table, it is stated that the meal caused either blindness or overheating. In this latter case, however, the quantity fed was more than is ordinarily recommended, and this may have been responsible for the trouble. In all cases, except two where expressions were not given, the results obtained were very satisfactory from the standpoint of the working capacity, efficiency and condition of the animals. In one case, it was stated that a financial saving was effected.

Letters submitted to these same parties after a lapse of eighteen months stated that the results from feeding the meal were equally as satisfactory as before. In one case, the feeding had been discontinued. This came about from the fact that an epidemic broke out among the stock, and the meal was eliminated from the ration as a matter of precaution. The company, as well as their veterinary adviser, considers, however, that the trouble was not caused by feeding cottonseed meal.

Results Obtained by Other Station Workers.

It is stated by C. W. Burkett[1] that cottonseed meal can be used to displace part of the corn in the ration for horses and mules. Two pounds of meal are recommended per animal daily. This amount should be fed with grain or sprinkled on dampened hay or ensilage. When animals can be made to acquire a taste for cottonseed meal it is recommended to make it a part of the ration.

The conclusions reached by W. J. Kennedy, E. T. Robbins, and H. H. Kildee[2] were that cottonseed meal gave better results than linseed meal as a supplement to the ration for work stock. The ration containing the cottonseed meal was fully as palatable and efficient and it was less laxative than the oil meal ration. It was also cheaper, when the cottonseed meal was selling at $30.00 per ton. The statement is made in the beginning of the bulletin, however, that the experiments have not been continued for a sufficient length of time to give definite conclusions. This work was carried on through two years.

C. W. Burkett[3] reports the feeding of oats, wheat bran, corn, gluten feed, linseed meal, and cottonseed meal in various forms to work stock. Fairly good results were obtained with all the mixtures fed, however, cottonseed meal was less satisfactory than any other supplement used in the rations.

---

[1] N. C. Sta. Bul. 189, p. 104.
[2] Ia. Sta. Bul. 109, p. 435.
[3] N. H. Sta. Bul. 82, p. 34.

W. C. Stubbs[1] fed cottonseed meal to horses and mules with satisfactory results. From one to two pounds were fed to animals daily with satisfaction. Six pounds is regarded as the maximum quantity which should be fed and this amount should be reached gradually. It is stated that reddish and musty cottonseed meal should be avoided.

F. E. Emery[2] reports feeding two pounds of cottonseed meal daily in a mixed ration. When the meal was increased to three and one-half pounds per day, the results were not as satisfactory as when two pounds were fed. The statement is made that neither of the horses fed cottonseed meal showed any bad symptoms from the meal feeding.

E. R. Lloyd[3] fed two lots of mules on cottonseed meal in connection with wheat bran. Lot 1 was fed wheat bran and cottonseed meal in the proportion of 1:1. The mixtures were eaten sparingly at first, and at the end of six weeks were practically refused. The mules were not accustomed to wheat bran and it was thought this might account for their refusing the meal. Corn chops were substituted, however, for the bran, but they still refused to eat enough of the mixture to keep them in good working condition. At the end of ninety days the mules were losing in flesh so rapidly that the cottonseed meal feeding was discontinued.

Dr. Gebeck[4] states that it has been proven that cottonseed meal can be fed to draft animals, especially during the time they are working excessively hard. Horses can be fed about two pounds per day, without harmful effects.

J. H. Connell[5] states that he has fed cottonseed meal to work stock in small quantities. The meal was gradually introduced in the ration to allow the stock to grow accustomed to the taste and odor. By following this practice, a large percentage of the work stock can be induced to eat it regularly although some refuse it entirely. He further states that large amounts have been fed safely to mules.

A number of other statements are made bearing on the results obtained from farmers of that State. While some of the results obtained are antagonistic to the use of cottonseed meal for work stock, considerable evidence is given in support of the value of the meal for this purpose. The average ration recommended should contain about one-tenth part of cottonseed meal by weight.

Judge Henry C. Hammond,[6] of Augusta, Ga., reports that he has fed for years about one pound of cottonseed meal daily to colts, brood mares, driving and work horses. There has been no sickness among the horses and their style, action and health are all that could be desired. He attributes his unvarying success to the fact that the meal is never fed alone but is always carefully mixed with some light concentrate.

---

[1] Louisiana Planter (1902), p. 178.
[2] N. C. Exp. Sta. Bul. 109, pp. 425-426.
[3] Miss. Ann. Rpt., 1902, pp. 16-18.
[4] Landw. Vers. Sta., 42, p. 294.
[5] Tex. Exp. Sta. Bul. 55, p. 206.
[6] Feeds and Feeding, Tenth Edition, Henry, p. 150.

This latter statement is of special importance. It is corroborated by a large amount of data obtained by the writer during three years experimental work.

Baron E. d'Allinges[1] fed two pounds of cottonseed meal to horses and mules during three years. It was fed in connection with 4 pounds of wheat bran and 6 pounds of corn meal. On Sundays whole corn, oats and uncut hay were fed. It is reported, however, that the use of cottonseed meal was not altogether satisfactory in this combination.

General Results Obtained from Feeding Cottonseed Meal.

The foregoing digest of the published matter relating to the use of cottonseed meal for horses and mules should have considerable weight, considering the sources of the information. Taking also the supplementary data from practical farmers who have used the meal in large quantities under varying conditions, there seems to be no large amount of evidence contradictory to the successful use of cottonseed meal for the purpose in question.

While in some instances antagonistic statements have been made, the writer is of the opinion that these negative expressions have at times been caused by the careless use of the meal. For example, some writers have advocated the use of as much as four to six pounds per animal daily. The concentrated nature of cottonseed meal would seem to oppose the recommendation of using such large quantities of it. This statement is especially true considering the undesirable effect of other more widely used concentrated feeds on working animals. As cottonseed meal is a heavy finely divided nitrogenous feed mature judgment should always be used in feeding it. It should be given in moderate amounts and in combination with light bulky feeds which will reduce the sodden condition of the meal when fed in large quantities.

On the whole, there is a certain amount of information concerning the use of cottonseed meal which every farmer must acquire for himself. However, if the use of the meal is based on the results given herein and on the experimental results reported by the writer in Bulletin 215, the successful use of it should be considerably increased. Cottonseed meal is a feed which should be given with great care, and when so used it should bring uniformly satisfactory results, although in some cases even under the most careful guidance it may be refused by work animals.

---

[1] Tex. Exp. Sta. Bul. 55, p. 205.

Some Cottonseed Meal Rations.

The following daily rations for a draft animal of medium weight doing moderate work should prove satisfactory under normal conditions.

Ration 1.

10 pounds corn-and-cob meal.
2 pounds cottonseed meal.

Ration 2.

8½ pounds corn-and-cob meal.
2 pounds wheat bran.
1½ pounds cottonseed meal.

Ration 3.

8½ pounds corn-and-cob meal.
2 pounds brewers' grains.
1½ pounds cottonseed meal.

Ration 4.

9½ pounds ear corn.
3 pounds wheat bran.
1 pounds cottonseed meal.

In using ration 4 it will be preferable to feed the wheat bran and cottonseed meal, thoroughly mixed, at the noon or night feed. If fed at night a small amount of the ear corn ration might well be given at this time. The roughage portion of the ration may be eaten *ad libitum*, the principal portion of it being fed at night.

It will be found advisable to mix the concentrates in 100 or 200 pound lots or even in larger quantities. This will save time in mixing, and the rations will be more convenient to feed.

S
97
.E2

THIRTY-FOURTH ANNUAL REPORT

of the

North Carolina Agricultural Experiment Station

of the

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

for the

YEAR ENDING JUNE 30, 1911

Including

Scientific Papers and Bulletins 209, 210, 211, 212, 213, 214, 215, 216

WEST RALEIGH, NORTH CAROLINA

RALEIGH
Edwards & Broughton Printing Co., State Printers
1912